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PHYSICS ABSTRACTS

SECTION A
of
SCIENCE ABSTRACTS

SECTION A, PHYSICS
SECTION B, ELECTRICAL ENGINEERING

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VOLUME 57 **DECEMBER 1954** NUMBER 684

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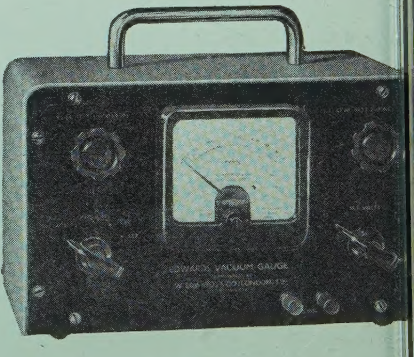

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Mechanical engineering
Illumination

LIST OF JOURNALS

The following list supplements the List of Journals published with the January number of Volume 56 (1953) and the Supplement published with the Index to Volume 56 (1953). Reprints of the List of Journals (1953) and the Supplement (1953) can be obtained from the Institution of Electrical Engineers, Savoy Place, London, W.C.2, price 2s. 0d. post free.

The addresses given are believed to be correct at the date of publication, but no responsibility can be accepted for errors.

Ann. Fac. Sci. Univ. Toulouse	*Annales de la Faculté des Sciences de l'Université de Toulouse.* Gauthier-Villars, 55 Quai des Grands-Augustins, Paris.
J. Coll. Arts Sci. Chiba Univ. Nat. Sci. Ser.	*Journal of the College of Arts and Sciences, Chiba University: Natural Science Series.* Konakadai-machi, Chiba City, Japan.
Publ. sci. tech. Minist. Air [*France*]	*Publications Scientifiques et Techniques du Ministère de l'Air.* Service de Documentation et d'Information Technique de l'Aéronautique. Magasin C.T.O., 2 Avenue de la Porte-d'Issy, Paris (15^{e}).
TMC tech. J.	*TMC Technical Journal.* Telephone Manufacturing Company, Hollingsworth Works, Dulwich, London, S.E.1.

New Journal

J. Instn Elect. Engrs (new series)	*Journal of the Institution of Electrical Engineers*, Savoy Place, London, W.C.2. Volume I (new series), Number 1, to be dated January, 1955. Monthly. Annual subscription £1 5s. 0d.; single numbers 5s. 0d.

Errata

Author Index (1952), p. 1137, line 28, and p. 1193, line 9: *for* INDIVINA *read* INDOVINA.
Abstr. 1767 (1954), line 4: *for* (*Aug.*, 1953) *read* (*Aug.*, 1952).
Abstr. 7028 (1954, line 3: for CASTRO, L. *read* CASTRO, A. L.
Abstr. 7347 (1954), line 3: *for* R. A. BRICE *read* B. A. BRICE.
Abstr. 8436 (1954), line 3: *for* G. C. VEKSLER *read* G. S. VEKSLER.
Abstr. 8579 (1954), line 1: *for* **gold bombardment** *read* **gold by bombardment.**
Abstr. 9107 (1954), line 3: *for* N. L. PACHOMOVA *read* N. L. PAKHOMOVA.
Abstr. 9302 (1954), line 2: *for* VONFOENSTER *read* VONFOERSTER.
Abstr. 9882 (1954), line 2: *for* P. L. STRATONOVICH *read* R. L. STRATONOVICH.
Abstr. 10478 (1954), line 6: *for* photon-pair *read* photon pair.

Corrections to Articles

Corrections have been published, as shown below, to the articles whose abstract numbers are given. Unless otherwise stated, the volume and page given refer to the journal named in the abstract, i.e. the journal in which the original article was published.

Abstr. 3640 (1948): **22,** 1626 (*Sept.*, 1954).
Abstr. 6741 (1953): **22,** 1625 (*Sept.*, 1954).
Abstr. 8363 (1953): **22,** 1629 (*Sept.*, 1954).
Abstr. 3310 (1954): **22,** 1791 (*Oct.*, 1954).
Abstr. 4818 (1954): **22,** 1791 (*Oct.*, 1954).
Abstr. 5759 (1954): **95,** 1705 (*Sept.* 15, 1954).
Abstr. 6742 (1954): **95,** 1706 (*Sept.* 15, 1954).
Abstr. 8446 (1954): **95,** 1705 (*Sept.* 15, 1954).
Abstr. 9378 (1954): **239,** 735 (*Sept.* 20, 1954).
Abstr. 9440 (1954): **22,** 1791 (*Oct.*, 1954).
Abstr. 10327 (1954): **25,** 1345 (*Oct.*, 1954).

MATHEMATICS 51

517.6

10713. Applications of the Dirac delta function to the evaluation of certain integrals. M. R. Spiegel. *J. appl. Phys.*, **25**, 1302–6 (*Oct.*, 1954).

The evaluation of certain integrals is attained by use of ordinary linear differential equations having inputs that depend on the Dirac delta function. The method is illustrated by several examples. A.

517.63

10714. Elementary observations on symbolic calculus. F.-H. Raymond. *Ann. Télécomm.*, **9**, 194–6 (*July–Aug.*, 1954) *In French.*

Some aspects of the teaching of symbolic calculus are given and its applications to certain modern techniques. After some preliminary remarks on Laplace transforms a form of Abelian theorem is stated which is important in practice. Assuming linearity a fundamental form of the theorem of superposition is obtained. The link is established between the image of the derivative of the indicial response and the impedance or coefficient of isomorphic transfer.

A. V. BREHME

518.2

10715. Nutshell tables of mathematical functions for interpolation with calculating machines. R. A. Hirvonen. *Bull. geod. internat.*, *No.* 30, 369–92 (*Dec.*, 1953).

Taylor tables of functions. The numerical values to ten decimal places of simple functions can be obtained from tables that cover only one page if a curvilinear interpolation be applied, in striking contrast to the familiar tables which fill hundreds of pages. Only the interpolation formula must be adapted in a form convenient for calculating machines and the usual scheme of differences replaced by a set of coefficients A, B, C . . . proportional to the higher derivatives. The table can be prepared very rapidly for any function of one variable (excepting, of course, those with short period disturbances). The tables can be used for numerical differentiation and integration also. A.

518.2

10716. Four-place tables of transcendental functions. W. Flügge. *London: Pergamon Press* (1954) 136 *pp.*

"Contains values, to slightly more than sliderule accuracy, of those functions which are most likely to occur in a great many problems of physics and engineering. It also contains a collection of formulae needed to handle the functions." Contents: Trigonometric and hyperbolic functions; Exponential and logarithm; Bessel functions; Thomson functions; Elliptic integrals; Miscellaneous (erf x, $C(x)$, $S(x)$, $\mathrm{Ei}(-x)$, $\overline{\mathrm{Ei}}(x)$, $\mathrm{Ci}(x)$, $\mathrm{Si}(x)$, $\Gamma(x) = y!$).

518.2 : 517.63

10717. Tables of coefficients for the numerical calculation of Laplace transforms. H. E. Salzer. *Appl. Math. Ser. Nat. Bur. Stand.*, *No.* 30, 36 *pp.* (1953).

518.2 : 519.2

10718. Probability tables for the analysis of extreme-value data. *Appl. Math. Ser. Nat. Bur. Stand. No.* 22, 32 *pp.* (1953).

518.2 : 519.2

10719. Tables of normal probability functions $\frac{1}{\sqrt{2\pi}}e^{-\frac{x^2}{2}}$ **and** $\frac{1}{\sqrt{2\pi}}\int_{-x}^{x} e^{-\frac{\alpha^2}{2}}\,d\alpha$. *Appl. Math. Ser. Nat. Bur. Stand.*, *No.* 23, 344 *pp.* (1953).

518.4 : 536.2.01

10720. Two-dimensional non-stationary fields of the equation of thermal conduction. Graphical integration methods for the solution of parabolic differential equations with three independent variables. A. Richter. *Arch. Elektrotech.* [*Berlin*] **41**, *No.* 5, 258–81 (1954) *In German.*

The numerical solution of the equation

$$\frac{\partial\theta}{\partial t} = a\left(\frac{\partial^2\theta}{\partial x^2} + \frac{\partial^2\theta}{\partial y^2}\right) + W/c\gamma$$

using difference methods with appropriate nomograms is described. The calculations are extended to include the cases of variable heat sources, anisotropic bodies and spatially variable substances. The effect of surface conditions is also considered. The method described is applied to the problem of a cylindrical coil with metal core in the initial stages after the current is switched on and the spatial distribution of the magnetic field and of the eddy currents is calculated. The dependence of permeability on field strength is considered. Two particular cases of the cooling of a metal cylinder of finite length are taken as examples and the results for the temperature distribution as determined by the graphical numerical method and by analytical methods are compared. S. WEINTROUB

518.5

10721. A calculator for aiding matrix calculations. J. C. Robb. *Trans Faraday Soc.*, **50**, 8–12 (*Jan.*, 1954).

An apparatus is described in which a number of standard calculators are arranged in a battery, their individual movements being so ganged as to make possible the simultaneous multiplication of coefficients set on each machine by a common factor. This materially assists in carrying out matrix calculations of various types. A.

518.5 : 519.2

10722. An electronic roulette for applying the Monte-Carlo method to nuclear physics. J. M. Tharrats, J. M. López Roca and V. Herrero Climent. *Nuovo Cimento Suppl.*, **11**, *No.* 3, 451–79 (1954) *In Spanish.*

Describes electronic devices for producing random numbers. These are used in the study of problems arising in connection with nuclear physics.

V. G. WELSBY

518.5 : 519.241.1 : 621.372.54 : 621.317.79

10723. A new method of determining correlation functions of stationary time series. D. G. Lampard. *Instn Elect. Engrs Monogr. No.* 104, 7 *pp.* (*Aug.* 16. 1954) [To be republished in *Proc. Instn Elect. Engrs C*].

The method is based on an expansion of the correlation function in a suitable orthonormal system. The coefficients in this expansion are shown to be simply related to the convolution integrals which arise when the given time series are applied to linear filters whose impulse responses are members of this orthonormal system. A very simple scheme for measuring these coefficients is proposed. It is further shown how a complex filter, whose impulse response is of the same shape as the desired correlation function, can be built up in a systematic way when these coefficients have been determined. Two examples of filter systems whose impulse responses are members of a Laguerre system are presented, and finally a description of a practical autocorrelator built around one of these filters, and some results obtained with it, are given. A.

518.5 : 537.543

The physics of cathode-ray storage tubes. *See Abstr.* 11162

518.5 : 621.3.012.8 : 621.372.4/.5

10724. Resistance-network analogues with unequal meshes or subdivided meshes. G. Liebmann. *Brit. J. appl. Phys.*, **5**, 362–6 (*Oct.*, 1954).

A general method for deriving the finite difference approximations to the partial differential equation div K grad $U = g$, which is solved by resistance-network analogues, is applied to find the resistance values and the currents which have to be fed in for (x, y)- and (r, z)-networks with unequal mesh sizes. Two ways of subdividing a network into finer meshes in the ratio 1 : 2 are then given, and a network subdivision in the ratio 2 : 5 is described. Experimental tests have shown that these subdivisions introduce negligible errors into the measured field distributions. A.

519.2

10725. Note on the factorial moments of standard distributions. R. B. Potts. Note in *Austral. J. Phys.*, **6**, 498–9 (*Dec.*, 1953).

519.2 : 535.1

10726. On the theory of the transmission of information and its applications to certain domains of physics. A. Blanc-Lapierre. *Ann. Inst. Poincaré*, **13**, *No.* 4, 245–96 (1953) *In French.*

The essential aspects of Shannon's theory are outlined; the extension from the discrete to the continuous case is effected by means of the interpolation theorem; the properties of stochastic functions limited to a certain frequency band are then investigated. Finally, the theory is applied to optics. T. J. REY

519.2 : 537.542

10727. Counters with random dead time. A. Ramakrishnan. *Phil. Mag.*, **45**, 1050–2 (*Oct.*, 1954).

The problem of determining the probability distribution function $\pi(n, t)$ of the number of registered events n in a time interval t when the dead times following the registered and unregistered events are themselves stochastic variates is solved using a method developed recently [Abstr. 8181 (1953)]. A.

519.2 : 621.372.54 : 621.391

10728. The statistical properties of the output of a frequency-sensitive device. G. R. Arthur. *J. appl. Phys.*, **25**, 1185–95 (*Sept.*, 1954).

Frequently it is desirable to know the statistical properties of the output of certain frequency-sensitive devices when some type of random signal is impressed. Since most devices of this type are followed by low-pass filters, this problem is one of determining the statistics of a filtered signal. The problem of finding the probability density of the difference of two dependent random variables has not been solved in any general way. Also, the problem of finding the statistical properties of the output of a linear filter upon which a non-Gaussian random signal is impressed has been considered by only a very few writers. The first sections give a solution of the case of a frequency discriminator with no low-pass filter, excited by a narrow band spectrum, and is solved by expressing the output of the device as the difference of two independent random quantities, which allows the use of the characteristic function method. The later sections contain a solution of the problem when a low-pass filter is present at the discriminator output. This is done by obtaining the predominant moments of the density from a series expansion which gives a good approximation to the nature of that density. Also, in this regard, the approach of the density to a Gaussian one, as the output filter band is made very narrow, is clearly shown. A.

519.281

10729. Efficiencies in the method of grouping. P. G. Guest. *Austral. J. Phys.*, **6**, 361–70 (*Dec.*, 1953).

The efficiencies obtained in curve fitting by the method of grouping are discussed in terms of two parameters χ_2, χ_3 which specify the departure from uniform spacing. For polynomials of the first and second degree the efficiencies practically always exceed 0·7, but the efficiencies for the third degree polynomial may be less than this value if the spacing is markedly non-uniform. A.

519.281

10730. Method of averages and its comparison with the method of least squares. M. Morduchow. *J. appl. Phys.*, **25**, 1260–3 (*Oct.*, 1954).

It is shown, under fairly general conditions, that the standard deviation of the residuals of the straight line fitting a set of points with uniformly spaced abscissas by the method of averages is at most $2\sqrt{3}$ times as great as the standard deviation of the least-squares line. Theorems of significance in the practical use of the method of averages are proved in the course of the analysis. A.

ASTRONOMY . ASTROPHYSICS . GEODESY 52

523.1 : 538.3

The motion of magnetic fields. *See Abstr.* 11221

523.11

10731. On the relative size of cosmic mass agglomerations. D. ter Haar. Letter in *Observatory*, **74**, 128–9 (*June*, 1954).

It is assumed that proto-systems originated in the turbulent elements of cosmic gas. After the formation of a proto-system no sub-systems are formed until increased density allows the formation of smaller turbulent elements. With suitable assumptions it is then possible to give tentative estimates of the masses of galaxies, star clusters, stars and planets.

R. A. NEWING

523.11

10732. On the significance of Newtonian cosmology. D. LAYZER. *Astron. J.*, **59,** 268–70 (*Aug.*, 1954).

Discusses the applicability of Newtonian mechanics to cosmological problems. It is shown that the so-called Newtonian cosmology of Milne and McCrea is internally inconsistent even if all its physical premises are granted. "Newtonian" derivations of the Einstein–Friedmann equations are therefore invalid. On the other hand, by virtue of two relativistic theorems, due essentially to H. Bondi, one can legitimately use the mathematical apparatus of Newton's theory to obtain the exact solutions of cosmological problems belonging to a certain well-defined class. A.

523.162.2

10733. Astrophysical considerations regarding Freundlich's red-shift. W. H. MCCREA. *Phil. Mag.*, **45,** 1010–18 (*Oct.*, 1954).

Were the red-shift of lines in the spectra of astronomical light sources, given by a formula proposed by Freundlich [Abstr. 5210 (1954)], a consequence of photon–photon interaction as Freundlich presumes it to be, it is shown that in the case of eclipsing binary stars there would result certain large effects that are certainly not observed. Also, were the energy lost in the reddening to reappear as radio-emission, this emission in the case of the Galaxy would conflict with observation as regards both quantity and distribution. However, since only parameters of the radiation-field appear in the formula, if the effect is not produced by photon–photon interaction it is doubtful whether it exists at all. It is shown, in fact, that it does not agree with the variation of the measured shift across the solar disk, and that the agreement with observation claimed in the cases of certain other stars is uncertain. It is then pointed out that the existence of the gravitational red-shift and the existence of the cosmic recessional red-shift are demanded by very general physical principles and that, consequently, the interpretation of the relevant observations does not require the existence in addition of the universal red-shift postulated by Freundlich. Born's interpretation of the postulate suggests an interesting association of the effect with radio-emission; but it is pointed out that the possibly significant feature in Born's suggestion could be independent of Freundlich's postulate. In spite of these criticisms of general aspects of Freundlich's discussion, the actual phenomena to which he directs attention call for much further investigation, both observational and theoretical. A.

523.162.2

10734. On the observational data relating to Freundlich's proposed red-shift law. E. M. BURBIDGE AND G. R. BURBIDGE. *Phil. Mag.*, **45,** 1019–22 (*Oct.*, 1954).

The observational data used by Freundlich in deriving the numerical constant in his proposed red-shift law are critically discussed in the light of the most recent information available. Some of the astronomical data used by Freundlich to adduce support for his proposed law [Abstr. 5210 (1954)] are also critically discussed. Apart from the term due to the gravitational red-shift, it is shown that all the spectral line-shifts considered by Freundlich can be accounted for by relative motions of stars or by motions within stellar atmospheres. A.

523.162.2

10735. Some more remarks on Freundlich's red-shift. D. TER HAAR. *Phil. Mag.*, **45,** 1023–4 (*Oct.*, 1954).

See two preceding abstracts. It is pointed out (i) that there seem to exist certain definite line-shifts in stellar spectra which cannot be accounted for by existing astrophysical theory; (ii) that in those cases where one would expect to be able to find the relativistic gravitational red-shift, only an effect which is much smaller has been observed; (iii) that apart from McCrea's arguments against photon–photon scattering as the explanation of the Freundlich effect one can adduce other arguments against this explanation. A.

523.162.2 : 523.877

10736. I. On the red-shift of spectral lines. E. FINLAY-FREUNDLICH. **II. Theoretical remarks on Freundlich's formula for the stellar red-shift.** M. BORN. *Nachr. Akad. Wiss. Göttingen math. phys. Kl. II,* **1953,** *No.* 7, 95–108. *In German.*

For I see Abstr. 4140 (1954).

II is an expanded account of the interpretation already suggested for the red shift [Abstr. 5211 (1954)] with emphasis on the possible significance for radio astronomy of the secondary radiation associated with the photon–photon collisions. R. A. NEWING

523.165

10737. The radio brightness distributions over four discrete sources of cosmic noise. B. Y. MILLS. *Austral. J. Phys.*, **6,** 452–70 (*Dec.*, 1953).

Brightness distributions have been obtained across the four radio sources, Cygnus-A, Taurus-A, Virgo-A and Centaurus-A, using a two-aerial interferometer of a special type in which the aerial spacing and the azimuth angle of the axis may be varied over a wide range. Radio isophotes have been constructed for three of the sources from these results, making some simple assumptions as to their form. The isophotes bear some relation to optical features of the nebulae with which the sources have been identified and their radio and optical sizes are similar. The remaining source, Cygnus-A, is unfavourably situated for observations from Sydney, and the results are less complete. A.

523.165

10738. Radio astronomy conference. J. P. HAGEN. Note in *Science*, **119,** 588–600 (*April*, 1954).

Jointly sponsored by the National Science Foundation, the Carnegie Institution of Washington and the California Institute of Technology, and held in Washington, Jan. 4–6, 1954. Subjects discussed included: discrete sources of radio radiation of both galactic and extragalactic origin; problems and theory in radio astronomy; aerial and equipment problems; galactic research.

523.165 : 523.5 : 523.72

10739. Radio astronomy. Edited by A. C. B. Lovell. *Occ. Notes Roy. Astron. Soc.*, **3**, *No.* 16, 33–79 (1954).

A collection of ten articles giving a general account for non-specialists of the techniques used and discoveries made in the last ten years. Illustrated by diagrams and photographs, but with only a short general bibliography.

523.165 : 523.852

10740. The distribution of radio brightness across the Crab nebula. J. E. Baldwin. *Observatory*, **74**, 120–3 (*June*, 1954).

The distribution of brightness in the region of the Crab nebula on 1·4 metres wavelength has been investigated with two interferometer axes at right angles, the ranges of separation being 10–300 λ E–W, 3–40 λ N–S. The curve of relative amplitude against separation indicates a source of angular diameter $\sim$5′ with a structure extending over $\sim$2°. The difference of apparent R.A. of the centre of brightness of the region with a spacing of 6 λ and the apparent R.A. with larger spacings shows that the extended source is asymmetrically disposed with respect to the main source, and is probably due to general galactic structure in the region. The close agreement of apparent R.A. with spacings between 12 λ and 200 λ on various wavelengths shows that the distribution across the main source is symmetrical, and that there is no subsidiary source of relative intensity >5% between 5′ and 3° in R.A. or ½° and 10° in Dec. from the Crab source. The radio brightness distribution across the Crab nebula is derived on the assumption of radial symmetry. M. W. OVENDEN

523.165 : 538.566

10741. Galactic radiation at radio frequencies. V. The sea interferometer. J. G. Bolton and O. B. Slee. *Austral. J. Phys.*, **6**, 420–33 (*Dec.*, 1953).

For Pt IV, see Abstr. 4869 (1952). The factors involved in the study of discrete sources of galactic noise by the sea interferometer are discussed. Three new forms of sea interferometer which increase the effectiveness of this technique are described. A.

523.165 : 551.510.535

Ionospheric refraction of 81·5 Mc/s radio waves from radio stars. *See Abstr.* 11624

523.51 : 545.827

10742. The uranium content of a stone meteorite. T. van Dijk, C. de Jager and J. de Metter. *Mem. Soc. Roy. Sci. Liège*, **14**, *Special No.*, 495–505 (1954).

An attempt was made to measure the U content of a Monze meteorite by the nuclear emulsion technique. This was too low to measure with precision, the most probable value being 3 to 6×10^{-8} g per g of meteorite.

523.59

10743. Measurements of the inner zodiacal light during the total solar eclipse of February 25, 1952. W. A. Rense, J. M. Jackson and B. Todd. *J. geophys. Res.*, **58**, 369–76 (*Sept.*, 1953).

Photographs of the skylight in the vicinity of the eclipsed sun were taken during the total eclipse of Feb., 1952, at a point in the shadow path near the Red Sea in Saudi Arabia at an altitude of 32 000 ft. A photometric analysis of the photographs yielded information about the intensities and degree polarization of the zodiacal glow between 5°·5 an 13° from the sun. The data are consistent with th planetary dust-cloud theory of the origin of the ligh and tie in previous observations of the glow beyon 30° of the sun with those of the solar corona with 3° of the sun.

523.

10744. Variations of the daily level of the 10· centimetre solar emission. A. E. Covington an W. J. Medd. *J. Roy. Astron. Soc. Canada*, **48**, 136– (*July–Aug.*, 1954).

The daily level of the solar radio flux at a wav length of 10·7 cm consists of a slowly varying co ponent associated with the appearance of sunsp and a basic minimum level originating from t undisturbed solar surface. For the period 1947–19 both components show a decline which has be associated with the decline of the sunspot cycle.

523

10745. The soft X-radiation from the undistur solar corona. G. Elwert. *Z. Naturforsch.*, 637–53 (*July–Aug.*, 1954) *In German.*

Theoretical criteria of the physical processes volved in both continuous, and line, X-radiation fr the solar corona are discussed. Ionization by collis plays a prominent role in the high-temperat excitation mechanism responsible for the emissior soft X-rays from the corona. Line-emissions in wavelength-range, 50 Å–300 Å, from highly exc atoms of He, C, N, O, Ne, Mg, Si and Fe are c sidered probable; and computed wavelengths for th elements are tabulated. D. R. BAR

52

10746. Note on solar granulation. R. N. Tho *Bull. Acad. Roy. Belgique Cl. Sci.*, **40**, *No.* 6, 62 (1954) *In French.*

On Schatzman's acoustic theory [Abstr. 7080 (19 the upper limit of size of granule is a criterion of acoustic opacity of the solar atmosphere in the considered. The presence of a secondary correla maximum at an interval of $\sim$15 000 km, fro study of transverse velocities in the turbulence th of Frenkiel–Richardson–Schwarzschild (1952), gests the existence of a network of convection with this characteristic diameter. D. R. BA

52

10747. Correlation analyses of turbulent velo and brightness of the photospheric granulation. E Stuart and J. H. Rush. *Astrophys. J.*, **120**, 24 (*Sept.*, 1954).

Data on the space distributions of turbu velocities and brightness of photospheric granul published by Richardson and Schwarzschild (were subjected to correlation analyses. When l scale fluctuations were minimized by smoothing o tions, the remaining small-scale fluctuation velocity and brightness were found to be corre by a coefficient of $-0{\cdot}68$. This result associate bright granules with outward-moving material. cross-correlogram function for smoothed brigh and velocity data revealed a maximum at 230 the autocorrelogram function for the smo velocity data alone confirmed this result, sugge the existence of a regular granular structure of this dimension. Autocorrelogram analyses of brightness fluctuations in the granulation, derived from plates obtained by W. A. Miller, revealed a maximum at about 14 000 km; this result is related to the finding by Frenkiel and Schwarzschild (1952) of a 15 000-km wavelength in the velocity distribution referred to above. A.

523.745

10748. Photospheric magnetic fields preceding other solar activity. D. E. Billings. Note in *Astrophys. J.*, 120, 184 (*July*, 1954).

Discussion of two magnetograms of the sun, published by H. W. Babcock [Abstr. 1962 (1954)] and obtained in July, 1953, which show an interesting relation of extensive magnetic fields to other solar activity not only at the time of the magnetic observations but also much later. One of the magnetograms, for instance, shows that photospheric magnetic fields preceded sunspots, flares, plage and coronal-line emission by at least one solar rotation. It is concluded that such observations should prove of great value for the prediction of solar-terrestrial relationships, and for the better understanding of the basic physical processes involved in the formation of active solar centres. A. BEER

523.746

10749. A statistical investigation of sunspot observations with special reference to H. Alfvén's sunspot model. P. Whittle. *Astrophys. J.*, 120, 251–60 (*Sept.*, 1954).

After a brief account of the properties of the autoregressive scheme, a double autoregression is fitted to the observed sunspot intensities in the northern and southern solar hemispheres. The results obtained confirm H. Alfvén's theory of sunspot generation and give evidence of a number of new phenomena. A.

523.75

10750. The variation of the total monochromatic emission of the solar corona within the 11-year cycle. II. The line 6374 Å. M. Waldmeier. *Z. Astrophys.*, **35,** *No.* 1, 1–9 (1954) *In German.*

For Pt I, see Abstr. 2874 (1950). This variation, observed during the cycle 1939–1950, is rather small: at its maximum value the emission is about 1·5 times that at minimum. A double period becomes evident. The principal maximum (1947) coincides with the maximum of the general sunspot activity, and the principal minimum with the minimum of this activity. The secondary minimum, however, as well as the secondary maximum (1942–43), occur on the descending branch of solar activity, immediately preceding the sunspot minimum. It is stated that the principal maximum is due to large electron density and the secondary to low temperature. A. BEER

523.75

10751. The temperature of the low chromosphere. L. Goldberg. Note in *Astrophys. J.*, **120,** 185–7 (*July*, 1954).

Recent observations of the Lyman α-radiation from high-altitude rockets by Byram, Chubb, Friedman and Gailar [Abstr. 27 (1954)] support the available evidence for a temperature model of the general type proposed by Woolley and Allen [Abstr. 3280 (1950)]. These rocket observations consist of absolute intensity measurements with photon counters, telemetered to the ground from altitudes up to 128 km. The results are consistent with a model chromosphere in which the temperature is at first constant with height, maintaining the boundary value of the photosphere up to a height of at least 4000 km, and afterwards increases to approximately 6000°K at a height of 6000 km. A. BEER

523.75

10752. Some characteristics of solar flares. C. S. Warwick. *Astrophys. J.*, 120, 237–44 (*Sept.*, 1954).

Solar flares and limb events are studied in relation to radio noise at 200 Mc/s and to SID's (sudden ionospheric disturbances). It is found that rising prominences are often associated with radio noise. SID's show a definite preferred association with the larger, brighter flares, and there is some indication that radio noise also favours these flares. However, either radio noise or an SID may be associated with a very small, faint flare. No lower limit is found (other than observational) of flare area or of intensity in the flare frequencies and no lower limit for association with radio noise or an SID. It is concluded that any minimum value for area or for intensity of a brightening required for definition as a flare must be arbitrary. A rapid rise to maximum and a long lifetime are found to be characteristic of large, bright flares. There is no significant asymmetry either in the number of flares appearing east or west of the solar meridian or in the number of coincidences with radio noise or fade-outs for flares near either limb. There is no significant difference between the number of coincidences with radio noise or fade-outs for flares near the limb and the number for flares near the centre of the disk, indicating that the noise-producing radiation and the fade-out-producing agency are non-directional. A.

523.774

10753. A new determination of the abundance of deuterium in the solar atmosphere. C. de Jager. *Mem. Soc. Roy. Sci. Liège*, **14,** *Special No.*, 460–7 (1954).

The only wavelength in the solar Fraunhofer spectrum where a deuterium line might be visible at all is in the wing of H_α. If the small depression observed at $\lambda = 6561{\cdot}03$ Å is ascribed to deuterium, then the solar abundance A_D is $1{\cdot}45\times10^{-4}$, a value which is of the same order as the terrestrial value, $1{\cdot}5\times10^{-4}$. If the observed depression in H_α is caused by another element, $A_D \leqslant 7\times10^{-5}$.

523.774

10754. Photoelectric observations of the profile of Hα in the sun's spectrum. A. K. Pierce. *Astrophys. J.*, **120,** 233–6 (*Sept.*, 1954).

The profile of Hα in the sun's spectrum for the centre of the disk is tabulated. The wings of the line show a depression of 1% at ±40 Å from the line centre. The central core of the line is asymmetrical with the minimum intensity at −0·037 Å. A.

523.851

10755. A note on globular clusters. S.-S. Huang. *Astron. J.*, **59,** 241–3 (*Aug.*, 1954).

A statistical relation between the total masses and the diameters of globular clusters has been used to derive the dependence on the radii of the root-mean square velocities of stars in the clusters. If the relative velocity of the stars in a cluster represents the turbulent motion in a prestellar gaseous medium from which the clusters were formed, the result indicates a Kolmogoroff spectrum of turbulence in that medium. A.

523.851

10756. One dimensional self-gravitating star systems. K. H. Prendergast. *Astron. J.*, **59**, 260–2 (*Aug.*, 1954).

The general solutions of the Boltzmann and Poisson equations are given for the case of a plane-parallel self-gravitating star system in a steady state. [See also Abstr. 3290 (1950).] A.

523.877

10757. The integral equations of Milne for a perfectly diffusing atmosphere. P. B. Bouvier. *Arch. Sci.* [*Geneva*] **6,** *No.* 5, 262–8 (1953) *In French.*

Given a diffusing atmosphere of albedo unity, it is shown how the basic Milne equations applicable to grey-body radiative transfer in an isotropic diffusing medium may be applied, after suitable transformation, to the problem of non-isotropic diffusion in the given direction, θ, when the relation between angle, θ, and phase, p, is of the form, $p = 1 + \cos^2 \theta$.

D. R. BARBER

523.877

10758. The mean molecular weight of star material. R. Kurth. *Experientia*, **10,** *No.* 9, 363–4 (1954) *In German.*

On account of the electrostatical forces between the ions and electrons in the interior of a star, the mean molecular weight μ should be given a higher value than is usually assumed. It is believed that a satisfactory theoretical calculation of μ has not yet been given, and that it does not seem to be possible. The determinations of the chemical composition of the stars are regarded as shaky, because they are based on the value of μ. A.

523.877

10759. A possible clue to the Wolf–Rayet atmosphere from flare and auroral mechanisms. M. Johnson. *Observatory*, **74,** 124–7 (*June*, 1954).

In place of the classical (shell) interpretation of the Wolf–Rayet emission spectrum, it is suggested that the observed wide-band emissions originate from ionized gas-streams in dense, deep regions of the W–R atmosphere, and result from luminous discharges excited by strong electrostatic fields. According to Giovanelli (1948) such voltages can be produced locally at points where the general magnetic field of the star is annulled by the local ionic field. In these "neutral" areas flare-discharges occur which, when integrated over the entire stellar area, yield the ambient emission characteristic of W–R spectra. The very great band-widths observed are due predominantly to Stark-broadening from the multiple discharges at high current-density: although a part of this broadening has a Doppler origin which is indicative of sudden expansion at the site of each flare, rather than around the whole star as in classical theory. D. R. BARBER

523.877

10760. The structure of stars with negligible content of heavy elements. A. Reiz. *Astrophys. J.*, **120,** 342–52 (*Sept.*, 1954).

In order to explain the location in the H–R diagram of the population II high-velocity subdwarfs of *F*-type, in terms of their chemical composition (low abundances of heavy elements), a stellar model has been constructed which is built on the assumption of negligible heavy-element content. This assumption implies that the opacity is caused mainly by free-free transitions and electron scattering and that the energy production is given by the proton-proton reaction. It is found that the configuration falls in the region of the H–R diagram where the subdwarfs are located. Causes of deviation of the stellar model from actual subdwarf stars are briefly discussed. A.

523.877

10761. On the gravitational stability in a rotating isothermal medium. W. Fricke. *Astrophys. J.*, **120,** 356–9 (*Sept.*, 1954).

The wave propagation of a disturbance in a rotating isothermal medium, which is stratified in plane-parallel layers symmetrical to a central plane with maximum density, is studied. The conditions for gravitational instability are deduced. A.

523.877 : 523.852

10762. Instability of non-radial oscillations of centrally condensed stars. R. C. Khare. *Proc. Nat. Inst. Sci. India*, **20,** 326–35 (*May–June*, 1954).

The differential equations governing small non-radial adiabatic oscillations of gaseous spheres are derived correctly to the order of accuracy to which changes in the gravitational potential produced by such oscillations can be ignored. They are then applied to the Roche Model in which practically the whole mass is concentrated at the centre and in the surrounding atmosphere density varies as the inverse square of the distance from the centre. It has been shown that for the general value of γ—the ratio of specific heats, the problem seems to be intractable. Next the case for the particular value of $\gamma = 1 \cdot 5$ is considered and it is shown that with a certain restriction on the form of the frequency function the amplitude of oscillation diverges from zero at the centre of the star to infinity at the surface. The oscillations are thus unstable. On the basis of this investigation, it has been suggested that the expansion of the Crab Nebula, the Filamentary Nebulae, the Planetary Nebulae and others may have its origin in the instability of non-radial oscillations that might have started in the remote past in centrally condensed stars due to some internal cause or due to the nearly passage of another star. A.

523.877 : 539.17

10763. Nuclear processes in the stars. *Mem. Soc. Roy. Sci. Liège*, **14,** *Special No.*, 546 *pp.* (1954).

Communications presented at the fifth International Colloquium of Astrophysics, held at Liège, Sept., 1953. For abstracts of some of the papers, see Abstr. 9884–5, 9892, 9896–9, 9901, 10484–5, 10742, 10753, 10763, 11177, 11579 (1954). The titles of the remaining papers are:

Part I. Origin of the elements. *The origin of the elements: a general survey*, J. Podolanski and D. ter Haar (19–41). *Physical conditions in the initial stages of the expanding universe*, R. A. Alpher, J. W. Follin, Jr and R. C. Herman (52–4); see Abstr. 3024 (1954). *Relation between modern cosmologies and nuclear astrophysical processes*, T. Gold (68–9).

Part II. Internal structure and evolution of the stars. Thermonuclear reactions. *Nuclear processes and stellar structure: general survey*, T. G. Cowling (75–87). *Inferences concerning thermonuclear reactions drawn from the theory of internal constitution*, H. Bondi (112–15); see Abstr. 9248 (1951). *Reactions of light nuclei and young contracting stars*, E. E. Salpeter (116–21). *Some remarks on the influence of electron-positron pairs on the internal constitution of very massive stars*, St. Temesváry (122–8). *Remarks on problems of vibrational stability*, E. Schatzman (163–9. *In French*); see Abstr. 6438 (1953). *Possible tracks of stellar evolution as a result of nuclear reactions*, A. G. Massewitch (170–86); see Abstr. 6002 (1951), 42 (1952). *Disturbances in dwarf stars caused by nuclear reactions and gas diffusion*, E. J. Öpik (187–99). *On the conditions of equilibrium at the centre of stars and their evolution*, P. Ledoux (200–12. *In French*); see Abstr. 7408 (1953). *Possible connection between meridional movements of sunspots and vertical mixing in the sun*, J. Tuominen (221–2). *Possible rate of corpuscular radiation of the sun*, E. R. Mustel (223–31). *Evolutionary trends in the H–R diagrams of galactic clusters*, G. R. Miczaika (275–82). *Remarks on evolutionary sequences [for extra-galactic nebulae]*, E. Vandekerkhove (283–92. *In French*).

Part III. Abundance of the elements in the stars. *Nuclear reactions affecting the abundance of the elements: general survey*, J. L. Greenstein (307–36). *The determination of the abundances of the light elements in early-type stars and gaseous nebulae*, L. H. Aller (337–57). *The determination of the relative abundance of helium in hot stars*, L. Neven (358–73. *In French*). *On the strength of the helium lines in the O-type stars*, A. B. Underhill (374–86). *The He–H abundance ratio in planetary nebulae*, K. Wurm (387–96). *The isotope C^{13} in stellar spectra*, G. A. Shajn and V. Hase (397–401). *On the carbon and S-type stars*, W. P. Bidelman (402–12). *A new lithium star*, M. W. Feast (413–16). *A spectrophotometric comparison between high and low velocity K giants*, L. Gratton (419–45). *Chemical composition and structure of the atmosphere*, C. Pecker (446–8. *In French*). *The rôle of the temperature gradient in the determination of abundances*, J. C. Pecker (449–51. *In French*). *The laboratory determination of relative transition probabilities of diatomic molecules*, J. Phillips (452–9). *Abundance of nitrogen in the solar atmosphere*, J. Gauzit (468–70. *In French*). *Note on the occurrence of technetium in the solar atmosphere*, H. Hubenet, C. de Jager and C. Zwaan (471–80). *On the deficiencies of elements in meteorites*, H. C. Urey (481–94). *On the abundance of chemical elements in the solar system*, A. Dauvillier (506–14. *In French*). *Supernovae as a source of cosmic rays*, J. S. Shklovsky (515–23).

525.722

10764. The scintillation of stars. J. van Isacker. *Publ. Inst. Roy. Météorol. Belgique, No.* 8, 110 *pp.* (1953) *In French.*

A statistical theory of stellar scintillation is developed (Chaps. I–III, 64 pp.) from the hypothesis of periodic changes of atmospheric refractive-index in a turbulent layer, ~10 km above sea-level. These fluctuations can be represented statistically by their autocovariant, or their power-spectrum. It is shown also that there result from the variation of refractive-index both positional, and luminous-intensity, fluctuations of the stellar image as seen by the unaided eye, or through a telescope; and that the observed frequency-distribution will be affected by the choice of objective aperture. In Chap. IV (20 pp.), the experimental results of Butler (1951), Mikesell, Hoag and Hall (1951), and Ellison and Seddon (1952) are discussed in relation to the statistical criteria developed earlier. Two final chapters (V–VI, 9 pp.) extend the theoretical treatment to cover scintillation of radio-stars and ionospheric "fading" phenomena.

D. R. Barber

525.722 : 551.510.535

10765. Scintillation of radio stars during aurorae and magnetic storms. C. G. Little and A. Maxwell. *J. atmos. terrest. Phys.*, **2**, *No.* 6, 356–60 (1952).

During aurorae, the scintillations of radio stars are, on the average, four times more rapid than during normal conditions. This increase in the scintillation rate is believed to result from a fourfold increase in the steady drift motion of the ionospheric irregularities which cause the scintillations. More generally, it is found that the scintillation rate, and the velocity of the ionospheric irregularities, are approximately proportional to the K index of geomagnetic activity. A.

525.722 : 551.510.535

10766. Galactic radiation at radio frequencies. VI. Low altitude scintillations of the discrete sources. J. G. Bolton, O. B. Slee and G. J. Stanley. *Austral. J. Phys.*, **6**, 434–51 (*Dec.*, 1953).

For Pt V, see Abstr. 10741 (1954). A study has been made of the scintillations of four discrete sources at altitudes of from 0 to 10°. The observations cover the years 1947–51 and were made at various frequencies in the range 40–300 Mc/s. It was found that the scintillation index, a measure of the amplitude of the scintillations, (1) increases with increasing wavelength, (2) decreases rapidly with increasing altitude, (3) shows seasonal and diurnal variations, the seasonal component having minima near the equinoxes and the diurnal component near dawn and sunset. The scintillation rate or the number of scintillations per minute (1) is different for sources of different declination, (2) is independent of wavelength. In the case of the Cygnus source, the data for which are the most extensive, the rate increases and the decline in the scintillation index with altitude is less rapid during the winter months. A strong correlation is established between the occurrence of the scintillations and sporadic E. The difference in the scintillation rates for different sources can be explained in terms of variations in the size of irregularities and the effects of the winds in the E_s layer. A.

PHYSICS 53

53

10767. Proceedings of the International Physics School of the Italian Physical Society (Varenna, 19 August–12 September, 1953). *Nuovo Cimento Suppl.*, **11**, *No.* 2, 143–450 (1954).

Hyperons and heavy mesons, C. F. Powell (165–97). *Remarks on the range-energy relation*, L. Vigneron (198–202). *The constant sagitta method*, C. C. Dilworth (203–6). *Causes of error in scattering measurements in nuclear emulsions*, R. L. Setti (207–11). *Measurements of specific ionization by photometry of nuclear tracks*, L. van Rossum (212–17. *In French*). *Magnetic deflection in nuclear emulsions*, M. Merlin (218–21). *Technique of nuclear emulsions*, A. Bonetti and G. Occhialini (222–7). *Recommendations for the standardization of measurements in photographic emulsions* (228–33). *Numerical tables of relations frequently used in nuclear emulsion work*, H. Fay, K. Gottstein and K. Hain (234–63). *V-particles and the cloud chamber*, P. M. S. Blackett (264–89). *The estimation of lifetimes from cloud chamber measurements*, J. A. Newth (290–6). *Comments on the design and operation of magnet cloud chambers*, J. A. Newth (297–308). *The measurement of cloud-chamber tracks*, K. H. Barker (309–18). *Counters without walls mounted inside a cloud chamber*, A. Loria (319–21). *The Wilson chamber with screens*, C. Peyrou (322–42. *In French*). *The use of the high pressure cloud chamber in cosmic ray investigations*, E. H. S. Burhop (343–56). *The diffusion cloud chamber*, A. Lovati and C. Succi (357–60). *Progress report on the development of bubble chambers*, D. A. Glaser (361–8). *Lectures on the primary cosmic radiation*, S. F. Singer (369–76). *On the fragmentations of heavy cosmic ray nuclei*, K. Gottstein (377–80). *The astrophysical aspect of cosmic radiation*, H. Alfvén (381–7). *Remark on the origin of the cosmic rays*, G. Wataghin (388–9). *Problems of nuclear geophysics*, F. G. Houtermans (390–405). *On the interaction of fast μ-mesons with matter*, E. Amaldi (406–14). *Some aspects of π-meson physics*, Y. Goldschmidt-Clermont (414–37). *Scattering of pions by nucleons and by nuclei*, G. Puppi (438–50).

FUNDAMENTALS 530.1

530.12

10768. The problem of many bodies and the superposition of spherically symmetric space-times in general relativity. H. TAKENO. *Progr. theor. Phys.*, **11**, 392–410 (*April–May*, 1954).

Puts forward a possibility of solving the problem of many bodies in general relativity by introducing the concept of the superposition of the space-times. An invariant theory concerning the superposition of the static spherically symmetric space-times is developed, having the centres of symmetry in common. Two operations are defined: (i) multiplication of a space-time by a constant and (ii) summation of two space-times, invariant-theoretically, and their consequences studied. Examples are given using the space-times frequently treated in general relativity. It is also shown that one can introduce invariantly various operations concerning these space-times beside the above two. Lastly another important rôle which this theory of superposition may play in general relativity is considered. A.

530.12

10769. Some properties of non-symmetric unified field theories. G. STEPHENSON. Letter in *Nuovo Cimento*, **12**, 279–84 (*Aug.*, 1954).

Three topics are considered: (i) the consequences of identifying $g_{\underset{\vee}{mn}}$ with the Maxwell 6-vector instead of with its dual are discussed, (ii) Einstein's 18 field equations involving two identities are replaced by 16 equations for the g_{mn}, (iii) the various possible generalizations of the equations $g_{mn;k}=0$ of general relativity are discussed and the only satisfactory case is found to be $g_{\underset{+-}{mn};k} = 0$. R. A. NEWING

530.12

10770. Born-type rigid motion in relativity. G. SALZMAN AND A. H. TAUB. *Phys. Rev.*, **95**, 1659–69 (*Sept.* 15, 1954).

Rigid motions of collections of particles as defined by Born, Herglotz and Noether are studied in special and general relativity. An approximate method for solving the field equations of general relativity, the equations of motion of a perfect fluid undergoing a rigid motion, and the boundary condition $p = 0$ is described and the first-order solution for the first two sets of equations is obtained. It is shown that in the classical limit the boundary conditions may be satisfied to this order. A.

530.12 : 523.11

10771. A new relativistic dynamic universe. L. CASTOLDI. *Geofis. pura appl.*, **26**, 1–9 (1953) *In Italian.*

A new relativistic theory of a time-variable universe is proposed, founded on the hypothesis of a constant total mass. Results are deduced in better agreement with astronomical data than those obtained by Friedmann's theory (1922) founded on the hypothesis of vanishing electromagnetical pressure. A.

530.12 : 530.14

10772. On the group of transformations in six-dimensional space. II. Conformal group in physics. Y. MURAI. *Progr. theor. Phys.*, **11**, 441–8 (*April–May*, 1954).

For previous part, see Abstr. 1012 (1954). The rôle of the conformal group in the theory of physics is emphasized for various reasons. The relation between this group and the group of transformations in six-dimensional pseudo-Euclidean space is shown. And as an illustration the theory of the non-local field is viewed through a concept of conformal group and it is shown that though in this way one can obtain equations, which the internal wave-function must satisfy; how to interpret them is yet open to question. A.

530.14

10773. Conservation laws in classical and quantum physics. E. P. WIGNER. *Progr. theor. Phys.*, **11**, 437–40 (*April–May*, 1954).

The relation between the conservation laws and the symmetry properties of space and time is examined.

If the simplest possible equation of motion takes the place of Newton's equation, the usual conservation laws are not obtained. In quantum physics, on the contrary, there is a superabundance of conservation laws and their physical significance is not obvious. A.

530.145

10774. Covariant integral equations for Heisenberg operators. R. J. Eden. *Proc. Cambridge Phil. Soc.*, **50,** *Pt* 4, 592–603 (1954).

Sets of rules are obtained for writing down directly the exact integral equations which are satisfied by certain functions of Heisenberg operators in quantum field theory. Three kinds of function are considered: the direct product, the chronological product and the *M*-product. The matrix elements of the *M*-product are equal to the Feynman amplitudes studied by Matthews and Salam (1953) and the corresponding integral equation is called here the Matthews–Salam (M–S) equation. These authors have given a symbolic form of the M–S equation and a method of repeated differentiation and integration which can be used to obtain the explicit form of the integral equation in any particular example. In practice their method involves an immense amount of calculation even in quite simple examples. The rules obtained in the present paper make it possible to write down directly the M–S equation without any of the tedious calculations implied by the M–S method. So long as the exact theory is used, the three sets of equations (for direct, chronological and *M*-products) are completely equivalent. When bound state theory is considered by an approximation based on a power series in the coupling constant different results are obtained. The approximation is inapplicable to the direct product equations, and leads to different approximate equations for the amplitudes obtained from the chronological and the *M*-products even when these amplitudes are identical. This paradox is explained and it is shown that the equation coming from the *M*-product corresponds to the Bethe–Salpeter equation. A.

530.145

10775. Representations of the anticommutation relations. L. Gårding and A. Wightman. *Proc. Nat. Acad. Sci. U.S.A.*, **40,** 617–21 (*July*, 1954).

All representations are obtained of the bounded operators, which satisfy $a_j a_k + a_k a_j = 0$, $a_j a_k^* + a_k^* a_j = \delta_{jk}$, when $j, k = 1, 2, \ldots, m$ for $m = \infty$. Some results on unitary equivalence and irreducibility are given, which show the existence of a maze of inequivalent irreducible representations. The one used in quantum physics is the only one for which the number of particles operator exists. P. T. MATTHEWS

530.145

10776. Representations of the commutation relations. L. Gårding and A. Wightman. *Proc. Nat. Acad. Sci. U.S.A.*, **40,** 622–6 (*July*, 1954).

The results of the previous note [see preceding abstract] are extended. All representations are given, and it is shown that there exist a maze of irreducible representations. P. T. MATTHEWS

530.145

10777. Use of causality conditions in quantum theory. M. Gell-Mann, M. L. Goldberger and W. E. Thirring. *Phys. Rev.*, **95,** 1612–27 (*Sept.* 15, 1954).

The limitations on scattering amplitudes imposed by causality requirements are deduced from the demand that the commutator of field operators vanish if the operators are taken at points with space-like separations. The problems of the scattering of spin-zero particles by a force centre and the scattering of photons by a quantized matter field are discussed. The causality requirements lead in a natural way to the well-known dispersion relation of Kramers and Kronig. A new sum rule for the nuclear photoeffect is derived and the scattering of photons by nucleons is discussed. A.

530.145

10778. Model of the causal interpretation of quantum theory in terms of a fluid with irregular fluctuations. D. Bohm and J. P. Vigier. *Phys. Rev.*, **96,** 208–16 (*Oct.* 1, 1954).

In this model, a set of fields which are equivalent in many ways to a conserved fluid, with density $|\psi|^2$, and local stream velocity, $d\xi/dt = \nabla S/m$, act on a particle-like inhomogeneity which moves with the local stream velocity of the equivalent fluid. By introducing the hypothesis of a very irregular and effectively random fluctuation in the motions of the fluid, it is proved that an arbitrary probability density ultimately decays into $|\psi|^2$. Thus an important objection to the causal interpretation, made by Pauli and others is answered. This result is extended to the Dirac equation and to the many-particle problem. A.

530.145

10779. Temperate distributions associated with the Klein-Gordon equation. A. Deprit. *Nuovo Cimento*, **12,** 335–50 (*Sept.*, 1954).

A distribution treatment is applied to the Klein–Gordon equation. The function $\Delta(x, t)$ is found to be the resolving distribution of the Klein–Gordon equation, considered as an evolution equation connected with the space convolution product. $\Delta_{\mathrm{ret}}(x, t)$ is the elementary kernel in the one-parameter algebra of operators which is associated with the Klein–Gordon differential operator. Finally $\bar{\Delta}(x, t)$ is shown to be one of the elementary solutions of the Klein–Gordon equation, which is now regarded as a space-time convolution equation. A.

530.145

10780. Spherically symmetric solutions in nonsymmetrical field theories. II. P. C. Vaidya. *Phys. Rev.*, **96,** 5–9 (*Oct.* 1, 1954).

For Pt I, see Abstr. 4591 (1953). The skew symmetric tensors satisfying the general criterion of spherical symmetry, derived in Pt I, contain certain arbitrary functions which indicate axial symmetry. These functions are removed. It is found that in addition to the "radial" components found by Papapetrou, the tensor has "transverse" components. In Maxwell's electrodynamics and in general relativity there are solutions which represent spherically symmetric fields of skew tensors with these transverse components. But in the unified field theories of Einstein or Schrödinger it is found that such solutions describing fields of skew tensors with non-vanishing transverse components do not exist. Thus the solutions found by Papapetrou, Wyman and Bonnor are the only spherically symmetric solutions allowed by the unified field theories. The spherically symmetric solution found in general relativity for a radiating star has no counterpart in the unified field theories. For comparison, it is noted that the same is the case with the field equations of Dirac's new electrodynamics. Spherically symmetric non-static solutions of Maxwell's electrodynamics have no counterpart in Dirac's electrodynamics. A.

530.145

10781. On the quantization of nonlinear equations. W. Heisenberg. *Nachr. Akad. Wiss. Gottingen math. phys. Kl. IIa*, **1953**, *No.* 8, 111–27. *In German.*

The problem of the anharmonic oscillator is put into the formalism of contemporary quantum electrodynamics, e.g. matrix elements of time-ordered products of operators are evaluated and quantities corresponding to the various Δ-functions of Feynman and Schwinger are given. Solutions are investigated in the case of weak coupling (a small anharmonic term) and of strong coupling. G. E. BROWN

530.145

10782. Symmetric algebra and second quantization of a system of bosons. A. Deprit. *Ann. Soc. Sci. Bruxelles I*, **68,** *No.* 1–2, 23–33 (1954) *In French.*

Methods applied by Valatin to a system of fermions [Abstr. 5078 (1951)] are extended to an assembly of bosons. It is shown that the method of second quantization differs from that of configuration space in that it is restricted to the symmetric algebra of the vector space of the single particle states.

P. T. MATTHEWS

530.145

10783. On gauge invariance and the structure of elementary particles. Y. Takahashi. *Progr. theor. Phys.*, **11,** 251–63 (*March*, 1954).

Non-gauge terms inherent in current field theory are discussed. An identity which holds, independently of the definition of integration, between the non-gauge term and the vacuum expectation value of the energy-momentum tensor of vacuum particles is derived and its physical meaning is discussed. A.

530.145

10784. The generalization of Stueckelberg formalism in the theory of quantized field. M. Hamaguchi. *Progr. theor. Phys.*, **11,** 461–75 (*April–May*, 1954).

A new method is proposed for overcoming the divergence difficulties in the interaction of elementary particles. A finite space time extension $\mathfrak{U}[\chi_\mu(\tau)]$ is introduced in each vertex of Feynman–Dyson graph, so that the usual S-matrix is transformed into the generalized form $S[\mathfrak{U}]$. $\mathfrak{U}$-extension is constructed by using the functionals $F[\chi_\mu(\tau)]$ with respect to proper time, and τ-region of its functional is taken analogously to that of Stueckelberg in his theory of finite time intervals. This method is first applied to the problem of self-energy of an electron, and the result is the same as introducing Feynman's cut-off procedure in the second order approximation, whereas in higher approximations results differ from that obtained by Feynman's cut-off method. A kinematical interpretation is proposed of the finite extension of the region of interaction, and a possible generalization of the present method is investigated, which will finally be applied to the problem of anomalous magnetic moments of the nucleon. A.

530.145

10785. On recurrence relations in field theory. D. J. Candlin. *Nuovo Cimento*, **12,** 380–6 (*Sept.*, 1954).

The relations between propagation functions given by Caianiello [Abstr. 6270 (1954)] are obtained in the interaction representation without the use of the perturbation expansion. They are also derived in the Heisenberg representation by variational methods. A.

530.145

10786. On the propagation functions of quantum electrodynamics. J. G. Valatin. *Proc. Roy. Soc. A*, **225,** 535–48 (*Sept.* 22, 1954).

Schwinger's equations for the propagation functions of quantum electrodynamics are redefined in a way to give the finite (renormalized) propagation functions without reference to divergent integrals or infinite renormalization constants. This is achieved by incorporating in the equations themselves a limiting process which is an extension of that introduced by Dirac and Heisenberg. The formulation is given independently of the power-series expansion, but the cancellation of singularities is established only in terms of such an expansion. The method is illustrated first by considering the lowest-order approximations. The lowest-order electron self-energy and vertex-part expressions are worked out, and the compensation of the singularities corresponding to the "*b*" divergences is indicated in the fourth order. In the power-series expansion, the prescriptions are in a one-to-one correspondence to those of Dyson. Their formulation independently of this expansion sums up the rules obtained in the different approximations. A.

530.145 : 537.2

10787. Quantum effects in the interaction between free electrons and electromagnetic fields. P. S. Faragó and G. Marx. *Acta phys. Hungar.*, **4,** *No.* 1, 23–30 (1954).

An electron beam shot through a transverse r.f. field suffers a direction spread. If experimental conditions are suitably chosen, the direction spread seems to be due only to the quantum dispersion of energy exchange between free electrons and r.f. field. A simple collector electrode system might allow not only the detection of the direction spread of the electrons, but the presence of a quantum effect might be checked by plotting the collector current versus r.f. field amplitude, the plot for the quantum effect being different from those for classical effects. A.

530.145

10788. Fredholm theory of Heitler's integral equation. S. N. Biswas. *Acta phys. Hungar.*, **4,** *No.* 1, 49–56 (1954).

The Fredholm theory of non-homogeneous integral equation has been applied to Heitler's integral equation for radiation damping in scattering processes which are beset with divergence difficulties. The general convergence of the solution has been discussed, from the mathematical point of view. The Fredholm solution has been obtained for various meson–nucleon scattering processes and it has been found that the results agree with those obtained otherwise. A.

530.145

10789. On the structure of the interaction of the elementary particles. V. Interaction of the second kind and non-local interaction. S. KAMEFUCHI. *Progr. theor. Phys.*, **11**, 273–87 (*March*, 1954).

By extending the same idea as in Pt IV [Abstr. 3109 (1954)] to the case of vertex corrections author examined to what extent the theory can be made less singular with such a method. The easiest example, the 4-vertex-interaction in meson pair theory, is discussed in detail. For this interaction an infinite number of counter terms must be introduced, but they can be brought into the form of the non-local interactions. Other approaches to non-singular theory are mentioned. A.

530.145

10790. On the universal Fermi interaction. O. HARA, T. MARUMORI, Y. OHNUKI AND H. SHIMODAIRA. *Nuovo Cimento*, **12**, 309–16 (*Sept.*, 1954).

It is shown that, by introducing the interaction in the form of the interaction of Urmaterie, a substance of higher level than elementary particles, the universal Fermi interaction with the combination $f_1(S - T + P) + f_2(S - A - P)$, where f_1 and f_2 are arbitrary constants, follows uniquely. A.

530.145

10791. Normal products of Heisenberg operators. J. C. POLKINGHORNE. *Nuovo Cimento*, **12**, 317–22 (*Sept.*, 1954).

The properties required of a normal product are discussed and a definition of the normal product of Heisenberg operators that fulfils these requirements is given. Rules for obtaining the differential equations satisfied by these products are stated. A.

530.145

10792. New Tamm–Dancoff formalism. A. KLEIN. *Phys. Rev.*, **95**, 1676–82 (*Sept.* 15, 1954).

The problems of renormalization and imposition of the boundary condition that the vacuum state is the comparison state for all energies are examined, using the example of the one-particle system. The boundary condition difficulty is expressed by the apparent occurrence of undesirable singularities in the interaction kernel obtained after elimination of higher amplitudes. Rules are derived for the construction of this kernel to any order in the coupling constant. It is shown by direct calculation that at least through fourth order the kernel is actually free of such singularities. Arguments are presented which indicate that this result may be expected to hold generally if higher amplitudes are eliminated by a consistent application of successive approximations. Even after transformation, however, the kernel does not agree with that obtained from the covariant one-body equation, and a new renormalization procedure will be required. A.

530.145

10793. Conservation of isotopic spin and isotopic gauge invariance. C. N. YANG AND R. L. MILLS. *Phys. Rev.*, **96**, 191–5 (*Oct.* 1, 1954).

It is pointed out that the usual principle of invariance under isotopic spin rotation is not consistent with the concept of localized fields. The possibility is explored of having invariance under local isotopic spin rotations. This leads to formulating a principle of isotopic gauge invariance and the existence of a **b** field which has the same relation to the isotopic spin that the electromagnetic field has to the electric charge. The **b** field satisfies non-linear differential equations. The quanta of the **b** field are particles with spin unity, isotopic spin unity, and electric charge ±*e* or zero. A.

530.145

10794. On the vector and pseudo-vector fields. K. H. TZOU. *J. Phys. Radium*, **15**, 559–62 (*July–Aug.–Sept.*, 1954) *In French.*

A vector or pseudo-vector field is considered with no supplementary condition. These fields represent a superposition of four spin states, three of total spin one, and one of spin zero. The explicit separation of these states is effected in the presence of a linear interaction with a spinor field. This is carried out in the interaction representation, which is easy to formulate owing to the absence of the supplementary condition. One then easily deduces the interaction representation with the usual supplementary condition of the vanishing divergence of the field.

P. T. MATTHEWS

530.145

10795. Families of spinor fields. T. KINOSHITA. *Phys. Rev.*, **96**, 199–201 (*Oct.* 1, 1954).

It is shown that a system of spinor fields can be classified uniquely into several sets, called families, when the interaction is given. This is made possible by noting that an interaction imposes some restriction on the commutation relation between different spinor fields. The fermion system is then classified, by a method of construction, into a set of families characterized by the following conditions: (1) Spinor fields of the same family anticommute with each other. (2) Commutation relations between any pair of spinor fields of different families are completely unspecified. To this end, a mathematical device is used which is derived from the self-evident requirement that equations of motion for fermions are determined unambiguously by the variation principle. The present method is applied to the classification of observed spinor fields and the structure of families is discussed in some detail. A.

530.145

10796. Evaluation of the collision matrix for Dirac particles in an external potential. B. ZUMINO. *Phys. Rev.*, **96**, 202–7 (*Oct.* 1, 1954).

The collision matrix for a quantized Dirac field in an external electromagnetic potential is evaluated by a method which utilizes the close relation between the theory of positrons and the formal one-particle Dirac theory. The main mathematical tool employed is a theorem by Baker and Hausdorff on exponentials of non-commuting quantities. One obtains the collision matrix expressed as a product of exponentials, involving creation and destruction operators in a way suitable for the calculation of matrix elements in the occupation number representation. In the Appendix the evaluation of the collision matrix for a real scalar field in interaction with a given source distribution is carried out by means of a similar technique. A.

530.145

10797. Anomalous magnetic moment of nucleon and nucleon isobar. A. Kanazawa and M. Sugawara. *Progr. theor. Phys.*, **11,** 231–43 (*March*, 1954).

The anomalous magnetic moments of nucleons are calculated, from the same standpoint as the author's previous work on pion-nucleon scatterings [Abstr. 5303 (1954)], where the Rarita–Schwinger field representing nucleon isobars is introduced and charge-independent interaction is assumed. In this paper the authors assume as the interaction Hamiltonian with external magnetic field the interaction energy of normal magnetic moments of nucleons and isobars with external magnetic field. Comparisons are made with results of covariant calculations in *ps–ps* theory, which clarify the validity of non-relativistic calculations and it is shown that the usual covariant perturbation calculation would not explain the anomalous magnetic moments of nucleons if the damping effect of nucleon pair creation and annihilation processes could be taken into account. In conclusion, anomalous moments seem to be explained for the first time by the introduction of nucleon isobars, which seem to have to be described as if they were purely elementary particles of spin $\frac{3}{2}$. A.

530.145

10798. On an expression for the total cross section. L. I. Schiff. *Progr. theor. Phys.*, **11,** 288–90 (*March*, 1954).

The well-known expression for the total cross-section in terms of the imaginary part of the coherent forward scattered amplitude is derived in a simple and general way from wave theory. The derivation also shows that there is a "shadow remnant" beyond the actual shadow, within which the forward coherent scattering intensity is diminished, of approximate radius $(r/k)^{1/2}$, where r is the distance from the scattering centre and $k = 2\pi/\lambda$ is the wave number. A qualitative understanding of the shadow remnant is obtained in terms of the uncertainty principle. A.

530.145

10799. On the construction of *S*-matrix in Lagrangian formalism. T. Imamura, S. Sunakawa and R. Utiyama. *Progr. theor. Phys.*, **11,** 291–308 (*March*, 1954).

Some differential equations with respect to a coupling constant g are written down in Lagrangian formalism. By integrating these equations *S*-matrix can be derived in two different forms; one is expressed in terms of the chronological symbol T^* (or P^*); the other in terms of T(or P). This treatment is applied to the system of local fields with non-local interactions. According to the result thus obtained, it seems necessary to make a further investigation on a new condition which ensures the existence of *S*-matrix. A.

530.145

10800. A tentative theory of Λ-particles. Theory of 4-dimensional τ-space. T. Nakano and R. Utiyama. *Progr. theor. Phys.*, **11,** 411–24 (*April–May*, 1954).

In order to describe new kinds of particles a four-dimensional Euclidian τ-space S_4 is introduced. Every elementary particle is supposed to be described by a particular irreducible spinor in S_3 which is imbedded in S_4 as a subspace. Any one wave-function is assumed to correspond to a particular one of the irreducible spinors in S_4, which will be decomposed into a sum of several parts, each one of which corresponds to a particular kind of elementary particle. In the present paper the nucleon and the Λ-particle are described by a single spinor corresponding to the representation $R_{1/2,\,1/2}(=\mathfrak{D}_{1/2,\,0}+\mathfrak{D}_{0,\,1/2})$ and the π-meson together with the θ-meson by an antisymmetric tensor in S_4. A.

530.145

10801. On the convergence of Born expansions. W. Kohn. *Rev. mod. Phys.*, **26,** 292–310 (*July*, 1954).

A study is made of the convergence of the Born expansions in collision problems involving a static central potential. The scattering of each partial wave, characterized by the phase shift η_l, is treated separately. Estimates of the radii of convergence of tan η_l and of $S_l \equiv e^{2i\eta_l}$ (as well as of the corresponding wave-functions) are established, and the truncation errors due to breaking off the Born expansions are investigated. An appendix deals with the expansion of η_l itself. A.

530.145

10802. Theory of multiple Coulomb scattering from extended nuclei. L. N. Cooper and J. Rainwater. Letter in *Phys. Rev.*, **95,** 1107–9 (*Aug.* 15, 1954).

Analysis of multiple scattering of high-energy particles (e.g. μ-mesons) is carried out taking into account the finite extension of the nucleus through a nuclear form factor employed to evaluate the single scattering. G. E. BROWN

530.145

10803. No-pair terms in the adiabatic nuclear potential. E. A. Power. *Nuovo Cimento*, **12,** 323–34 (*Sept.*, 1954).

A critical analysis is made of the controversial no-pair and non-adiabatic terms in the nuclear force problem. As a specific example the scalar theory is examined carefully. It is shown that the non-static corrections are required to the adiabatic local potential to give the correct phase shifts in Born approximation. A.

530.145

10804. High-energy expansions of phase shifts. E. Corinaldesi. *Nuovo Cimento*, **12,** 438–48 (*Sept.*, 1954).

The phase shifts of the Klein–Gordon and of the Dirac equation are developed in powers of the inverse of the momentum, following a method based on the iteration of an integral equation. The expansion is found to be possible only under somewhat restrictive conditions for the potential. A procedure is suggested by which, if the phase shifts for a certain potential are given, those for a large family of other potentials can be calculated by series expansions in powers of the inverse of the momentum. This method is seen to be rapidly convergent for small values of the angular momentum, and is relevant to recent calculations on the scattering of high-energy electrons by nuclei. A.

530.145

10805. Two-nucleon problem when the potential is nonlocal but separable. I. Y. Yamaguchi. *Phys. Rev.*, **95,** 1628–34 (*Sept.* 15, 1954).

The two-nucleon problem is considered in terms of an interaction of the form $(\mathbf{p}|V|\mathbf{p}') = -(\lambda/M)g(p)g(p')$.

In this case one can find exact solutions both for bound states and for continuum states, and prescribe arbitrarily and independently the interaction effective in states of different angular momenta. This important feature makes the analysis of scattering straightforward and unambiguous. An example for $g(p) = (p^2 + \beta^2)^{-1}$ is presented and compared with the low-energy neutron-proton data. The photo-disintegration of the deuteron in this model is also discussed. A.

530.145

10806. Meson-nucleon scattering in the Tamm–Dancoff approximation. F. J. Dyson, M. Ross, E. E. Salpeter, S. S. Schweber, M. K. Sundaresan, W. M. Visscher and H. A. Bethe. *Phys. Rev.*, **95,** 1644–58 (*Sept.* 15, 1954).

An attempt is made to calculate meson-nucleon scattering by using charge-symmetric pseudoscalar meson theory with pseudoscalar coupling and without the use of perturbation theory. The Tamm–Dancoff formalism is used, with all states which are not directly coupled to the one-meson, one-nucleon state omitted. In this approximation an inhomogeneous integral equation in three-dimensional momentum space is derived for $g(\mathbf{p})$, the probability amplitude for relative momentum $\mathbf{p}$ between meson and nucleon. This equation is reduced to a separate one-dimensional integral equation for each of the six angular momentum and isotopic spin (T) states, $S_{\frac{1}{2}}$, $P_{\frac{1}{2}}$ and $P_{\frac{3}{2}}$ for $T = \frac{1}{2}, \frac{3}{2}$. The phase shifts for these states are given by the value of $g(p)$ on the energy-shell. All self-energy and renormalization terms are omitted and the present method is inapplicable to the two states of total angular momentum and T equal to $\frac{1}{2}$. The integral equations are solved by semi-numerical methods for the $S_{\frac{1}{2}}$ and $P_{\frac{3}{2}}$ states with $T = \frac{3}{2}$, obtaining the shape of $g(p)$ and the variation of phase shift with energy and coupling constant. It is shown that only for the $P_{\frac{3}{2}}$, $T = \frac{3}{2}$ (corresponding to an attractive potential) is the phase shift much larger than in Born approximation and depends strongly on the coupling constant and on energy. For the other repulsive, states the phase shift is less than in Born approximation. For energies of about 150 MeV or more and for a large enough coupling constant, the $P_{\frac{3}{2}}$, $T = \frac{3}{2}$ phase shift is larger than any of the others. This is in rough qualitative (but by no means quantitative) agreement with experiment. A.

530.145

10807. Comparison of the cut-off meson theory with experiment. G. F. Chew. *Phys. Rev.*, **95,** 1669–75 (*Sept.* 15, 1954).

The cut-off theory for the interaction of pions with non-relativistic nucleons is tested against experiments involving a single nucleon, with and without the presence of an electromagnetic field. It is concluded that most of the existing information about the P-wave pion-nucleon interaction can be understood with a renormalized coupling constant, $f^2 = 0{\cdot}058$ and a cut-off energy, $\omega_{\max} = 5{\cdot}6\,\mu$. No light is shed on the S-wave pion-nucleon interaction. A.

530.145

10808. Bound states and the formal theory of scattering. M. N. Hack. *Phys. Rev.*, **96,** 196–8 (*Oct.* 1, 1954).

The exact expression for the transition rate for quantum mechanical scattering problems is derived formally without recourse to adiabatically switching on the interaction or averaging the initial state in time. The equivalence is shown of the stationary definition of the S-matrix and an appropriate definition by the time-dependent method. A.

530.145

10809. Generalized variational principle for the scattering amplitude. S. I. Rubinow. *Phys. Rev.*, **96,** 218–19 (*Oct.* 1, 1954).

The Schwinger variational principle in differential form for the S-wave phase shift has been generalized so as to be applicable to the entire scattering amplitude. A.

530.145 : 537.534.74

10810. Pseudoscalar interaction and proton-proton scattering. D. Basu. *Indian J. Phys.*, **28,** 201–4 (*May*, 1954).

It is shown here that in the nuclear interaction the presence of contact potentials of the form of δ-function helps to make the scattering isotropic as required to explain the p–p scattering at high energies. The δ-function potential which occurs naturally in the field theoretical interaction may be regarded as the analogue of the "hard core" potential which Jastrow assumed *ad hoc* in the singlet state only. A.

530.145 : 537.534.74

10811. Proton-proton scattering at 340 MeV. C. C. Banerjee. *Indian J. Phys.*, **28,** 221–6 (*May*, 1954).

The proton-proton scattering has been considered in this paper with an interaction which involves only the tensor part of the pseudoscalar interaction. The theoretical results have been compared with experimental data at 340 MeV. It is found that the tensor force alone can fairly explain the experimentally observed isotropy of scattering. It also explains qualitatively the independence of differential cross-sections with energies of the incident particles. A.

530.145

10812. The formulation of quantum mechanics in terms of ensemble in phase space. T. Takabayasi. *Progr. theor. Phys.*, **11,** 341–73 (*April–May*, 1954).

The formulation of non-relativistic quantum mechanics in terms of ensemble in phase space is established by clarifying the subsidiary conditions for the phase space ensemble to represent a pure state, and thereby the equivalent correspondence between this formulation and the alternative formulation in terms of quantum potential previously developed is demonstrated. A.

530.145

10813. Surfaces of equal phase in the "double solution theory." F. Fer. *C.R. Acad. Sci.* [*Paris*] **238,** 2286–7 (*June* 14, 1954) *In French.*

See Abstr. 5313 (1954). The space-time lines defined by de Broglie's "pilot wave equation" are the characteristic lines of a first-order partial differential equation whose integrals are the only surfaces on which two different solutions of the pilot-wave equation can be made equal in amplitude, phase, and first- and second-order (not higher) derivatives of the phase. This leads back to the definition of the trajectory of a mobile linear singularity. G. FIELD

530.145

10814. Simple solution of the generalized Schrödinger equations. M. Schönberg. Letter in *Nuovo Cimento*, **12**, 300–3 (*Aug.*, 1954).

This paper extends the idea of Madelung [*Z. Phys.*, **40**, *No.* 3–4, 322–6 (1926)], whereby the Schrödinger equation is associated with the irrotational motion of a hypothetical fluid. For the generalized Schrödinger equations [Abstr. 2038, 7125 (1954)] the fluid is considered and some simple two-dimensional vortex motions of this are considered. L. S. GODDARD

530.145

10815. Expansion of wave packets. D. S. Ling, Jr. *Phys. Rev.*, **96**, 216–17 (*Oct.* 1, 1954).

The Fourier coefficients of a wave packet are proved to be equal to the coefficients obtained when the wave packet is expanded in terms of a set of functions appropriate to a scattering problem. A.

530.152.15

10816. A general approach to hysteresis. D. H. Everett and W. I. Whitton. *Trans Faraday Soc.*, **48**, 749–57 (*Aug.*, 1952).

The general nature of hysteresis phenomena is outlined and definitions distinguishing between hysteresis and supersaturation are proposed. The relationship between these two phenomena is investigated in terms of a mechanical model, and it is postulated that hysteresis is to be attributed in general to the existence in a system of a very large number of independent domains, at least some of which can exist in metastable states. The features of this model which lead to hysteresis are analysed in terms of p.e. surfaces, and it is pointed out that similar surfaces will be observed for molecular systems if the p.e. is replaced by the chemical potential of the system. The thermodynamic implications of this model are considered briefly. A.

530.152.15

10817. A general approach to hysteresis. II. Development of the domain theory. D. H. Everett and F. W. Smith. *Trans Faraday Soc.*, **50**, 187–97 (*Feb.*, 1954).

The independent domain theory of hysteresis outlined in Pt I is developed to take account of a more general distribution of domain properties than that employed previously. The distinction between the present treatment, dealing with time-independent hysteresis, and classical relaxation theory is emphasized, and an approximate graphical method is outlined for the calculation of the behaviour of a system having given domain properties. Some general theorems are enunciated which govern the behaviour of a system, according to the present theory, and these are compared and contrasted with the conclusions reached by Duhem. The available experimental data are insufficient to determine the range of validity of the two theories, although two quantitative tests made recently in the field of adsorption hysteresis support the present model. A.

530.162

10818. A suggested modification of noise theory. J. Keilson. *Quart. appl. Math.*, **12**, 71–6 (*April*, 1954).

A class of stationary, equilibrium, Markoff processes is demonstrated, all of which have the same equilibrium distribution, $W_0(x)$, and correlation function $R(t) = E_0 \exp(-t/\tau_0)$ differing from each other in the number of zero crossings of the system per second. The processes are described by an integral equation characterized by a parameter γ. As γ approaches 1, the integral equation passes over into the Fokker–Planck equation, $\tau_0(\partial W/\partial t) = E_0(\partial^2 W/\partial x^2) + (\partial/\partial x)(xW)$. Since the number of zero crossings per second of the system becomes infinite as γ goes to one, the degenerate nature of the Fokker–Planck process is made evident. A.

530.162

10819. A method in quantum statistical mechanics. I. General theory. H. Ichimura. *Progr. theor. Phys.*, **11**, 374–84 (*April–May*, 1954).

A formal expansion method for the grand partition function of the system of interacting particles is developed, in which the number representation and the ordered exponential method are used. The resulting formula will be useful in calculating quantum effects statistical and dynamical, in the thermodynamical property of various systems. Applications to special problems will be given in later papers. A.

530.162

10820. A method in quantum statistical mechanics. II. The degenerate Fermi–Dirac assembly. H. Ichimura. *Progr. theor. Phys.*, **11**, 385–91 (*April–May*, 1954).

The method of Pt I is used to calculate the effect of the inter-particle interaction of the thermodynamic potential per particle of the highly degenerate Fermi–Dirac gas. It is shown that under certain assumptions the specific heat of the system of conduction electrons in a metal maintain its linear temperature dependence in the presence of the interaction. A.

530.162

10821. Direct cellular evaluation of the density of states in phase space and the accurate calculation of Fermi levels. L. Gold. *J. appl. Phys.*, **25**, 1278–80 (*Oct.*, 1954).

A new procedure for rigorously deducing the energy distribution of states, formulated upon a direct summing of cells in k space, provides a sound basis for assessing the classical approximation so familiar in statistical mechanics. It is thus established that the latter approach underestimates the density of states to the extent that the conventional Fermi energy calculation for electrons in metals is a few percent too high. A.

530.162

10822. On the molecular distribution functions of a one-dimensional fluid. II. A. Ramakrishnan and P. M. Mathews. *Phil. Mag.*, **45**, 1053–8 (*Oct.*, 1954).

The method of "basic functions" developed by one of us (Ramakrishnan) in Pt I [Abstr. 4235 (1954)] is used to derive the molecular distribution functions of a one-dimensional fluid with an intermolecular potential defined recently by Sells, Harris and Guth [Abstr. 138 (1954)]. It is shown that in the approach to the asymptotic form there is an essential difference between positive and negative potentials. A.

530.162

10823. Approximate variational principle in quantum statistics. W. M. MacDonald, III and J. M. Richardson. *Phys. Rev.*, **96**, 18–21 (*Oct.* 1, 1954).

The density matrix of von Neumann can be used to formulate an exact variational principle for quantum statistics which embodies the principle of maximization of entropy. Using the formalism of second quantization, one can write this variational principle for fermions or bosons and can then derive from it an approximate variational procedure which yields the particle states of a system of interacting bosons or fermions as well as the distribution of particles in these states. These equations yield the generalization of the Hartree–Fock equations for non-zero temperature and the corresponding extension to bosons. A.

530.162 : 519.2

10824. The statistics of scaled random events. R. O. Davies and J. W. Leech. *Proc. Cambridge Phil. Soc.*, **50,** *Pt* 4, 575–80 (1954).

When independent random events are scaled down by a factor *n*, the number of counts in a given time interval no longer obeys the Poisson Law. The correct distribution function is derived together with its moment-generating function and explicit formulae ($n = 2, 4$) for the first four moments about the mean. The theory is in agreement with experiments carried out with a scale-of-four counter. A more general treatment is given and is applied to find the variance for all even values of *n*. A.

530.162 : 536.75

10825. A central theorem of statistical mechanics. P. Jauho. *Ann. Acad. Sci. Fennicae, AI, No.* 172, 11 *pp.* (1954).

It is shown that in a quantum mechanical system with a constant volume the necessary and sufficient conditions for the identity of the two definitions of entropy, $\bar{S} = \int \frac{\delta Q}{T}$ and $S = k \log W$, are the requirements for the free energy of the system to be an extremum at equilibrium and for the determinant formed from the second derivatives of the free energy with respect to the occupation numbers to be different from zero. The theory of Schottky defects is used as an example. A.

GENERAL MECHANICS
MECHANICS OF SOLIDS 531

531.225

10826. Torsion of a shaft with a toroidal cavity. G. Weiss and L. E. Payne. *J. appl. Phys.*, **25,** 1321–8 (*Oct.*, 1954).

Gives the solution to the torsion problem for a near-cylindrical shaft of circular section having a toroidal cavity. Since the interpretation of the axially symmetric problem as a flow problem in 5 dimensions is well known, the first part of the paper is devoted to developing a method for handling the flow problem about an *n*-dimensional ring-shaped body of general cross-section. In the second part of the paper this method is applied to the case of an *n*-dimensional torus ring. The case $n = 3$ then yields the solution to the classical flow problem, and $n = 5$ gives the solution to the torsion problem under consideration. A.

531.258

10827. Effect of uniform displacement on the stress distribution of a wood plate. K. C. Walters and C. B. Smith. *J. appl. Phys.*, **25,** 1254–9 (*Oct.*, 1954).

The principle of virtual work was employed to determine the stress distribution in a wood plate subjected to a load distribution such as to effect a uniform displacement in the *y* direction. The displacement *u* along $x = \pm a$ developed an unexpected contour. The average value of *u* appears to occur near the ends. This cautions against the common practice of placing the instruments for measuring Poisson's ratio near the middle. In the case of isotropic material the unexpected contours still prevail but are barely perceptible. The work was carried out for a fourth approximation (not presented) with sufficient accuracy to ensure that the same contour was developing. A.

531.259 : 539.501

10828. Effect of rheological behavior on thermal stresses. A. M. Freudenthal. *J. appl. Phys.*, **25,** 1110–17 (*Sept.*, 1954).

Since the conventional elastic analysis of thermal stress problems coupled with limiting creep rates and time-dependent fracture stresses as (inelastic) design criteria, results in design procedures for thermal stresses (in heat exchangers, nuclear reactors, flight structures at supersonic speeds, etc.) of considerable unreality, the effect of various types of rheological behaviour (visco-elastic, plastic, work hardening) on the level of thermal stresses is analysed under simplified assumptions, such as uniaxial stress and polar or cylindrical symmetry. The effect on the thermal stress intensity of the rheological behaviour of the material is shown to be very significant, particularly with respect to stress relaxation and the development of residual stresses. A.

MECHANICAL MEASUREMENTS 531.7

531.714 : 539.434

10829. Design of extensometer for creep studies. B. R. Gossick. *Rev. sci. Instrum.*, **25,** 907–9 (*Sept.*, 1954).

The extensometer permits remote operation over a wide range of extensions. The creep specimen is mechanically coupled to a metal core within a mutual inductance bridge. The amount of deformation of the creep specimen determines the position of the core and thus the amount of bridge unbalance. The tolerances of mutual inductance bridges being imperfect, a residual voltage remains which is 90° out of phase with that produced by displacements of the core. A core which produces an output voltage 90° out of phase with the voltage produced by a steel core has been made with laminations of copper and steel. By connecting two bridges in series, one containing a steel core and the other the composite core, the null has been reduced to the noise level of the amplifier to which the bridge system is connected. Requirements for making the phase angle of the bridge signal approximately independent of core position, over the extension range, are discussed. A.

531.74

10830. The calibration of circular scales and precision polygons. A. H. COOK. *Brit. J. appl. Phys*, **5**, 367–71 (*Oct.*, 1954).

The theory of two methods of calibration is discussed and expressions are obtained for the values and standard deviations of the corrections to the nominal values of the angles. Ways of setting out the computations are also given. A.

531.764.5

10831. Ageing of quartz crystal vibrators. H. T. MITCHELL. Letter in *Nature* [*London*] **174**, 41–2 (*July* 3, 1954).

Experience with 100 kc/s quartz vibrators used in Post Office quartz clocks shows that there is a slow frequency change of the order of 1 part in 10^9 a day for a good clock to 1 part in 10^{11} a day for the best clock. The present note compares the frequency change of a GT-cut 100 kc/s crystal operated at its normal temperature of 50°C and at a temperature of −10°C. The ageing rates (in parts per 10^{10} per day) were about 50 at 50°C, 10 at −10°C and 80 when operated again at 50°C. A brief description is included of a novel method of maintaining the crystal at a steady temperature of −10°C. H. J. H. STARKS

531.767/.768 : 621.317.79

10832. Ultra-speed transient dynamic analyzer for mechanics and ballistics. J. C. LINDSAY AND A. V. MASKET. *Rev. sci. Instrum.*, **25**, 704–11 (*July*, 1954).

A photoelectronic apparatus has been developed which makes possible the continuous simultaneous measurement of the depth of penetration, the speed, and the deceleration of a non-deforming small-calibre projectile during armour penetration. The basic principle is to have the flight path of the projectile pass perpendicularly through a thin parallel light beam of uniform intensity which activates a vacuum-type phototube. The output of the phototube is proportional to position or the depth of penetration under appropriate geometry. A voltage signal derived from the phototube circuit is preamplified and differentiated to give voltage signals proportional to speed and deceleration. Permanent records of the signals are made by photography of cathode-ray tube traces and analysed. The apparatus is capable of measuring real transient accelerations or decelerations as great as 10^8 ft/sec^2 (3×10^9 cm/sec^2) with average error of 2%. Possible applications of the system to mechanical problems as an accelerometer, speed, and displacement measuring device are indicated. A.

531.787.6 : 621.317.79

10833. A sensitive micromanometer. S. T. NAISH. *Atomic Energy Res. Establ.* [*Harwell*] *Mem. GP/M*165, 3 + viii *pp.* (1954).

Describes modifications to a micromanometer which uses an electronic micrometer to measure the deflection of a diaphragm. A.

531.787.7

10834. Differential conductance manometer. J. R. PAPPENHEIMER. *Rev. sci. Instrum.*, **25**, 912–17 (*Sept.*, 1954).

The conductance manometer is designed to measure and record rapid changes of pressure in liquid systems. The manometer is symmetrical with respect to its moving member and is liquid filled throughout; it is therefore specially adapted to the measurement of differential pressures. Sensitive instruments with natural frequencies ranging from 60 to 500 c/s have been used for recording differential pressures in the circulatory and respiratory systems, for flow measurements, for the rapid determination of colloid osmotic pressures, and for other applications involving extremely small volume displacements. A.

MECHANICS OF FLUIDS 532

532.123

10835. Method for determining the viscoelastic properties of dilute polymer solutions at audiofrequencies. K. SITTEL, P. E. ROUSE, JR AND E. D. BAILEY. *J. appl. Phys.*, **25**, 1312–20 (*Oct.*, 1954).

A sensitive instrument for the measurement of the viscoelastic properties of dilute polymer solutions is described. It makes use of torsion pendulums with resonant frequencies in the range between 200 c/s and 2300 c/s. The test liquid is contained in a hollow oscillating disk. The shearing stress which is exerted at the liquid-metal interface alters the frequency and rate of decay of the free oscillations of the pendulum. By means of an optical system, the oscillations of the pendulum are caused to modulate the light striking the cathode of a phototube. The frequency and the rate of decay of the resulting alternating voltage are measured electronically. The operation of the instrument and the factors affecting the precision of measurement are analysed. A.

532.13 : 532.584

10836. The viscosity of suspensions of spheres: a note on the particle interaction coefficient. R. ST. J. MANLEY AND S. G. MASON. *Canad. J. Chem.*, **32**, 763–7 (*Aug.*, 1954).

Measurements of the reduced viscosity of suspensions of glass spheres 5 μ diameter have been made up to concentrations of 18% by volume. The experimental results yield the empirical equation $\eta_{sp}/c = 2 \cdot 50 + 12 \cdot 7c + \ldots$ The coefficient of c, due to interactions, is in fair agreement with a value of 10·05 based upon a modification of Vand's theory which takes into account the experimentally established mechanism of two-body collisions of spheres in a velocity gradient. Several reasons for the discrepancy are suggested. A.

532.13 : 532.77 : 541.64

10837. Non-Newtonian behavior of solutions of macromolecules. P. GOLDBERG AND R. M. FUOSS. *J. phys. Chem.*, **58**, 648–53 (*Aug.*, 1954).

Using the assumption that the viscosity of a non-Newtonian liquid may be expanded as a power series in rate of shear, equations are derived which permit determination of the initial coefficients of the series from experimental data obtained using capillary viscometers. It is shown that measurements made at the same value of (Rp/L) in different viscometers agree; here, R = radius and L = length of capillary, and p is driving pressure. Furthermore, it is shown that non-Newtonian behaviour of solutions can arise from molecular interaction or from a change of intrinsic viscosity with rate of shear; if the latter change is zero, plots of (η_{sp}/c) against c for different fixed values of $Q = Rp, g/2L\eta$ have the same intercept and if the interaction term vanishes, these curves have the same slope. In general, the (η_{sp}/c)–c curves at fixed Q have both different slopes and intercepts. Results on a number of systems indicate that the limiting dependence of apparent viscosity at low values of Q is linear in Q rather than quadratic. A.

532.13 : 532.77 : 541.64

10838. Influence of rate of shear on the apparent viscosity of A—dilute polymer solutions, and B—bulk polymers. F. BUECHE. *J. chem. Phys.*, **22**, 1570–6 (*Sept.*, 1954).

The measured viscosity of bulk polymers and their solutions varies with the magnitude of the applied shearing stress. In this paper it is shown that this is a natural consequence of the fact that the molecules are caused to rotate by the shearing action. This rotation gives rise to sinusoidal forces which alternately stretch and compress the molecules. The viscous behaviour of such a system is shown to be analogous to that of a spring immersed in a viscous medium and being acted upon by sinusoidal viscous forces. The problem has been treated quantitatively using the method of a previous paper. Good agreement is obtained between theory and experiment without the aid of adjustable parameters. It is found that, if the molecule is considered shielded, the theory accurately represents the experimental data for dilute solutions. The behaviour of the bulk polymer is well represented by means of the free draining approach. It is pointed out that the variation of the viscosity of dilute polymer solutions with the rate of shear may provide a convenient method for determining molecular weights of coiling type polymers. A.

532.13 : 537.212

10839. The effect of an electric field on the viscosity of liquids. III. E. N. DA C. ANDRADE AND J. HART. *Proc. Roy. Soc. A*, **225**, 463–72 (*Sept.* 22, 1954).

For Pt II, see Abstr. 1637 (1951). With polar liquids an electric field produces a small increase in viscosity which is proportional to the square of the field. The experiments now described confirm the viscoelectric effect established in the earlier communications and further show that the effect varies with the frequency, increasing from a finite value at zero frequency according to a simple parabolic law. The implications of the effect are discussed. A.

532.13 : 537.226.33 : 539.133

10840. Dielectric relaxation, viscosity and molecular shape. C. P. SMYTH. *J. phys. Chem.*, **58**, 580–2 (*Aug.*, 1954).

Although the dielectric relaxation time of a liquid tends to increase with increase in the measured or macroscopic viscosity, it is much smaller than the value calculated from the viscosity and molecular radius, probably because the molecular motion involved in dipole orientation requires much less translational motion of the molecules than that occurring in viscous flow. The relaxation times of nearly spherical molecules, which can rotate with little or no displacement of their neighbours, are found to show little dependence on the viscosity of the medium, in contrast to unsymmetrical molecules which displace their neighbours when they rotate. The van der Waals radii of six substituted methanes, which have nearly spherical molecules, have been calculated from atomic radii and bond lengths and used with the values of the critical wavelength to calculate the internal or microscopic viscosity which hinders dipole orientation. The values calculated for the microscopic viscosity from the critical wavelengths are only 0·008 to 0·06 of the macroscopic. Lowering of the molecular relaxation time by the internal field may lower the microscopic viscosity by a factor of about 0·7 for all of these liquids but dibromodichloroethane. There appears to be little parallelism between the microscopic and the macroscopic viscosities and, indeed, a crystalline solid consisting of nearly spherical molecules may have a microscopic viscosity lower than that of the liquid state. A.

532.13 : 539.32 : 541.64

10841. The dynamic bulk viscosity of polyisobutylene. R. S. MARVIN, R. ALDRICH AND H. S. SACK. *J. appl. Phys.*, **25**, 1213–18 (*Oct.*, 1954).

The dynamic bulk modulus of a high molecular weight polyisobutylene is calculated from measured longitudinal-wave and shear moduli. A viscous or energy-dissipating process associated with pure volume deformation is found, which appears to be a relaxation process. The peak in absorption of the shear and bulk moduli and the apparent activation energies associated with the two types of deformation are at least approximately the same, suggesting that the fundamental molecular mechanism involved in the two types of deformation may be the same. A.

532.14

10842. Density of liquids in the state of saturation. Investigations on the widening of the theorem of corresponding states. II. L. RIEDEL. *Chem.-Ingen.-Tech.*, **26**, 259–64 (*May*, 1954) *In German.*

For Pt I, see Abstr. 6555 (1954). In analogy to reduced vapour pressure, the reduced densities of different liquids in the state of saturation, when plotted against reduced temperature, do not yield a single curve but a single-parameter group of curves. As in the previous case, so also here, the introduction of the "critical parameter" makes it possible to obtain an equation for the group of curves. It is found that the value γ/γ_0 (density in relation to density at 0°K) is practically the same for all liquids in the temperature range up to $\theta = 0{\cdot}8$, the discrepancies being $\sim$1% at $\theta = 0{\cdot}95$. It is thus possible to obtain a function practically independent of the "critical parameter"; this function is represented by tables and discussed in detail. F. LACHMAN

532.51

10843. A note on the Karman's spectrum function of isotropic turbulence. K. M. GHOSH. *Proc. Nat. Inst. Sci. India*, **20**, 336–40 (*May–June*, 1954).

The general self-preserving form of the spectrum function governed by Heisenberg's equation for decay of turbulence at the stage when the effect of molecular viscosity is negligible, recently given by N. R. Sen, is found to be valid under the same condition for the more general decay equation proposed by Karman.

The form of the constituent function f of self-preservation depends on the arbitrary constants α and β introduced by Karman. The asymptotic behaviour of the self-preserving solution of Heisenberg's equation as $k \to 0$ still remains valid under certain inequality condition satisfied by α and β in the general case of Karman; but under the opposite condition a second behaviour of the asymptotic solution at $k \to 0$ is possible. For $k \to \infty$ the Kolmogoroff spectrum is obtained as a (transient) steady-state condition with finite transfer of equal amounts of energies between a spectrum band and its outside, but for Karman's spectrum function when $\beta/(\alpha - 1) > 3$, a second steady-state behaviour becomes mathematically possible at near the complete decay end of the spectrum. A.

532.51 : 534.39

10844. The equation of motion and the impulse theorem in viscous and compressible media. F. E. Borgnis. *Acustica*, **4,** 407–10 (1954) *In German.*

These are derived vectorially from the general expression for the stress tensor in a viscous medium with due consideration of the compressibility and the shear- and bulk-viscosities of the medium. Some remarks are added concerning the use of the one-dimensional specialization of the equations for an explanation of the hydrodynamic flow caused by acoustic waves. A.

532.57

10845. The model testing of electromagnetic flowmeters. W. Murgatroyd. *Atomic Energy Res. Establ.* [*Harwell*] *Rep. X/R* 1053, 6 + iii *pp.* (1953).

The voltage output of most electromagnetic flowmeters does not rigorously obey the simple equation generally used. This is particularly true when using liquid metals. A qualitative discussion indicates the sources of deviation. It is suggested that flowmeters should be designed from model tests, and the necessary testing criteria are derived. A tentative design is given for a standard flowmeter. It is recommended that some such standard be adopted, and that tests be carried out on this flowmeter, over as wide a range of variables as possible. Mention is made of a novel type of flowmeter, in which the only measurement made is the force on the magnet. The pros and cons of this are briefly discussed. A.

532.57 : 621.317.79

10846. The theory of the d.c. electromagnetic flowmeter for liquid metals. J. A. Shercliff. *Atomic Energy Res. Establ.* [*Harwell*] *Rep. X/R* 1052, 23 + iv *pp.* (1953).

In practical electromagnetic flowmeters the ratio of voltage output to flow quantity times field intensity is not a simple constant. This report investigates theoretically the variations of this ratio due to wall conductivity, contact resistance, the shortness of magnet pole-faces and the distortion of the velocity profile by electromagnetic forces in tubes of circular and rectangular section. Several points are still obscure, particularly the behaviour of turbulence. Some recent tests are examined in the light of the theory, and the influence of dimensionless groups is discussed. It is shown that the design of an accurately predictable flowmeter is possible, although such a meter would be uneconomic for routine use. A.

532.57 : 621.318.3

10847. Electromagnetic pumps and flowmeters. M. Greenhill. *Atomic Energy Res. Establ.* [*Harwell*] *Inf./Bib.* 93, 3 *pp.* (1954).

A bibliography of 22 literature references and government reports.

CAPILLARITY 532.6

532.6

10848. The rise of liquids into a wedge shaped crevice. D. Tollenaar. *Appl. sci. Res. A*, **4,** *No.* 5–6, 453–6 (1954).

A discussion of the problem by considering the crevice as a number of narrow vertical parallelopipeds. Absurd results are obtained if chances of contact of any parallelopiped with nearer neighbours are equated to chances of contact with remote neighbours. A photograph demonstrates horizontal flow of liquid from wider to narrower parts of a vertical wedge.

T. C. TOYE

532.612

10849. The variation of the surface tension of solutions with time. Solutions of alcohols. E. K. Rideal and K. L. Sutherland. *Trans Faraday Soc.*, **48,** 1109–23 (*Dec.*, 1952).

The changes of surface tensions with time of aqueous solutions of heptanol and 3-methyl-1-butanol are measured by the oscillating jet technique. It is shown that all such results depend upon the jets used, the rate of change in the surface tensions being greater than those predicted by diffusive processes. The nature and importance of solute transport by liquid motions in a jet are discussed. A.

532.612

10850. Relationship between the surface tension of metals and their atomic volume. S. N. Zadumkin. Letter in *Zh. éksper. teor. Fiz.*, **24,** *No.* 5, 615–16 (1953) *In Russian.*

Born's formula for the surface-tension coefficients of the NaCl-type ionic crystals is adapted to metals by substituting electrons for negative ions. In the formula obtained $\sigma = \alpha D/A$ (where $D =$ density, $A =$ atomic weight), the coefficient α has been evaluated from experimental data to average $7{\cdot}87 \times 10^3$ erg. cm (or nearly double Born's coefficient). The formula agrees with reliable experimental data within 5–10%. F. LACHMAN

532.612

10851. Calculation of the surface tension in the neighbourhood of equilibrium. R. Defay. *J. Chim. phys.*, **51,** 299–312 (*June*, 1954) *In French.*

A statistical mechanical treatment shows how *a priori* calculation of surface tension between a solution of known composition and a superficial layer not necessarily in equilibrium may be made. The method is shown to be suitable for perfect solutions as well as for solutions of molecules of different sizes. Particular solutions are given and the effect of heat of mixing is also accounted for. 30 references.

T. C. TOYE

532.613.2

10852. Liquid metals. I. The surface tension of liquid sodium: the vertical-plate technique. C. C. Addison, D. H. Kerridge and J. Lewis. *J. Chem. Soc.*, **1954**, 2861–6 (*Aug.*).

Describes the determination of the surface tension of liquid sodium in an atmosphere of pure argon, from measurements on plates of zinc, copper and molybdenum suspended, and partly immersed, in liquid sodium. In the temperature range 100–200° zinc can be fully wetted by sodium, but copper and molybdenum are not wetted; the technique employed for contact angles of 0° and 180° is described. The surface tension is found to be 195 dyne/cm at the melting point, and the temperature coefficient is 0·1 dyne.cm^{-1}.degree^{-1}. A.

532.68

10853. Exchange of liquid between paper pores. D. Tollenaar. Letter in *Appl. sci. Res. A*, **4**, *No.* 5–6, 457–8 (1954).

The author shows that for certain conditions Weijdema's formula [Abstr. 6331 (1954)] becomes identical with his own [Abstr. 5336 (1954)].

W. Good

MOLECULAR THEORY OF LIQUIDS 532.7

532.7

10854. The influence of molecular shape in the electrostatic theory of polar liquids. J. A. Abbott and H. C. Bolton. *Trans Faraday Soc.*, **48**, 422–30 (*May*, 1952).

An exact expression is derived for the reaction field of a point dipole lying along the axis of a prolate spheroidal cavity. Together with the known expressions for the cavity field this is applied to the theory of polar liquids and an equation derived allowing the molecular dipole moment to be calculated from experimental observations. The values of the moments so deduced are in better agreement with the moments measured in the gas phase than those deduced from the Onsager equation which uses a spherical model. The discrepancy is from 5 to 15% and it is concluded that this appears to be the limit of accuracy of a purely electrostatic theory of polar liquids. A.

532.7 : 539.213 : 548.0

10855. The density and refractive index of glycerine in the liquid, crystalline and vitreous states at low temperatures. A. K. Schulz. *J. Chim. phys.*, **51**, 324–7 (*June*, 1954) *In French.*

The density was measured between 90°K and 350°K by means of a "Boyle's Law" technique using gaseous hydrogen. The amorphous material was enclosed in a thin rubber membrane, and its expansivity was found to be 9×10^{-5} deg^{-1} below the transformation region (~ 180°K) and 50×10^{-5} deg^{-1} above it. The expansivity of the crystalline glycerine was 15×10^{-5} deg^{-1}. The refractive index of amorphous glycerine was measured by Pulfrich's method over the same temperature range and its molar refractivity varied by less than 1%. This result is regarded as a confirmation of the density measurements.

R. O. Davies

532.27

10856. Conditions under which dispersion of a solute in a stream of solvent can be used to measure molecular diffusion. G. Taylor. *Proc. Roy. Soc. A*, **225**, 473–7 (*Sept.* 22, 1954).

It is shown that an assumption made in the author's previous discussion [Abstr. 6530 (1953)] can be presented as a result of analysis. The conditions under which an approximate solution of the equations for diffusion in a moving fluid can be used to interpret longitudinal dispersion of a solute in a stream of solvent flowing through a tube is given as

$$4L/a \geqslant Ua/d \geqslant 6\cdot9.$$

Here U is the mean velocity, a the radius of the tube, D the coefficient of molecular diffusion. L is the length of tube over which appreciable changes of concentration occur. A.

532.73

10857. The statistical mechanical theory of molecular distribution functions in liquids. J. G. Kirkwood and Z. W. Salsburg. *Disc. Faraday Soc. No.* 15, 28–34 (1953).

The thermodynamic functions of liquids and liquid solutions are related to the potential of intermolecular force according to statistical mechanics by the Gibbs theory of the canonical ensemble. They may be formally expressed as integrals of the probability distribution functions $g^{(n)}/v^n$ for all subsets, n, of molecules in a canonical ensemble of average molecular density v^{-1}. When the intermolecular force can be represented as the sum of the forces between molecular pairs, a knowledge of the pair functions $g^{(2)}_{\alpha\beta}$ at all densities, for the several types of pairs $\alpha\beta$ composing a fluid mixture, suffices to determine the thermodynamic functions in terms of the potential of intermolecular force. The pair functions $g^{(2)}_{\alpha\beta}$ are known in the theory of liquids as the radial distribution functions. Systems of integro-differential equations for the distribution functions $g^{(n)}$ have been formulated in equivalent forms by Yvon, Kirkwood, Mayer, and Born and Green. These systems of equations have been approximately solved by closure with the superposition approximation in triplet space, with significant results. At low densities they may also be solved by Mayer cluster expansions in powers of the average densities. A new system of integral equations for the distribution functions $g^{(n)}$ is presented, which is based upon partial cluster expansions of the probability density in the canonical ensemble. For molecules possessing a rigid impenetrable core of radius b and an attractive force of finite radius a, the new cluster expansions are of finite degree ν, equal to the number of spheres of radius b which can be close packed in a sphere of radius a, and thus converge for all densities. All thermodynamic functions are expressed in terms of the small finite set of distribution functions $g^{(1)}, \ldots g^{(\nu)}$. Phase transitions are related to the eigenvalues of the kernels of the system of integral equations. A.

532.73

10858. The statistical mechanics of systems with non-central force fields. J. A. Pople. *Disc. Faraday Soc., No.* 15, 35–43 (1953).

A general method for investigating the thermodynamic effects of the dependence of the intermolecular potential on orientation is described. A systematic expansion of the angular dependent part of the intermolecular energy forms the basis of an approximate method of evaluating the partition function which is then used to discuss the thermodynamic properties of liquids and liquid mixtures. Although complete expressions for the intermolecular energies are not available, it is possible to draw certain general conclusions applicable to all types of directional forces. A simple relation is found connecting the additional cohesive energy due to directional forces with the consequent loss of entropy due to restricted rotation. A similar treatment of liquid mixtures leads to a relation between the heat, free energy and entropy of mixing which differs significantly from corresponding theories based on central forces. The theory is used to interpret some experimental data on mixtures in terms of intermolecular forces. A.

532.73

10859. Theoretical models and real solutions. R. L. Scott. *Disc. Faraday Soc., No.* 15, 44–51 (1953).

Various theoretical models of solutions (Hildebrand's regular solution, Guggenheim's strictly regular solution, Longuet-Higgins' conformal solution, and Prigogine and Mathot's cell model) are discussed and compared. To the first approximation, limited to first order terms in $(E_2 - E_1)/E$, all are equivalent. Volume changes on mixing at constant pressure are emphasized, particularly for dispersion-force solutions, where Prigogine and Mathot predict contraction on mixing. A.

532.73

10860. Lattice theories of liquids and solutions at low temperatures. J. S. Rowlinson. *Disc. Faraday Soc., No.* 15, 52–6 (1953).

Several modifications of the lattice theory of solutions are tested by comparing the corresponding theories of pure liquids with experimental results. The quantities tested are the configuration energy (*RT* minus the latent heat of evaporation), its rate of change with temperature, and the coefficient of thermal expansion of the liquid. Longuet-Higgins has shown that, with certain restrictions, these are related to the excess free energy, entropy and volume of a solution. To obtain good agreement for all these quantities, it is shown that a lattice theory of liquids must take into account the potential of all the neighbours of a given molecule, not only the nearest, and must not approximate this potential by replacing it with a smoothed square-well potential, or with the potential of a simple harmonic oscillator. Refined lattice theories, which allow for unoccupied sites, give the same results as simple theories at temperatures below the normal boiling point. A.

532.73

10861. The vapour pressures of athermal mixtures. G. S. Rushbrooke, H. I. Scoins and A. J. Wakefield. *Disc. Faraday Soc., No.* 15, 57–65 (1953).

On the basis of the quasi-crystalline model of athermal liquid mixtures of molecules of two different sizes, expressions are derived for the partial vapour pressures of the two components as power series in the volume concentration θ of the larger species. The coefficients of successive powers of θ are shown to be given by direct analogues of the functions β_k occurring in Mayer's theory of imperfect gases. The simplest approximation to β_k leads to the Flory vapour-pressure equations and the next most simple to those of Miller and Guggenheim. For monomer-dimer solutions sufficient β's have been calculated for closer estimates of the true predictions of the model to be obtained. For monomer-trimer and monomer-tetramer solutions the partial vapour pressures are found to depend, though apparently only slightly, on whether the larger molecules are rigid or flexible. A.

532.73

10862. Athermal mixtures. E. A. Guggenheim. *Disc. Faraday Soc., No.* 15, 66–72 (1953).

The close formal analogy proved by McMillan and Mayer between the power series for the osmotic pressure of a solution and for the pressure of a real gas masks the fact that in the former the effective interaction energy, which has to be used for the correct evaluation of the irreducible cluster integrals β_k, includes the work required to push around the solvent molecules and fit them into the spaces between the solute molecules. The solvent may not be treated as a continuum unless the smallest dimension of the solute molecules is great compared with the size of the solvent molecules. When this is not the case, the only treatment which has yet proved successful is the replacement of the cluster integrals by cluster sums, in other words the use of the quasi-crystalline model. In the case of athermal mixtures, this becomes the treatment described by Rushbrooke, Scoins and Wakefield, to which this paper may be regarded as a supplement. In particular the laws of ideal solutions are obtained when solute and solvent molecules are of the same size. A.

532.73

10863. Solutions of chain molecules—a new statistical theory. H. C. Longuet-Higgins. *Disc. Faraday Soc., No.* 15, 73–80 (1953).

From the assumption that in a mixture of long chain molecules of similar type, the probability distribution function for a pair of ends belonging to different molecules depends only on the temperature and density and not on the lengths of the two molecules, it is shown that the free energy of mixing at constant temperature and pressure must be of the form

$$(\Delta G)_{T,p} = kT \sum_i N_i \ln \phi_i,$$

where ϕ_i is the volume fraction of component *i*. For a binary mixture of chain molecules A and B of different type, provided the interactions between the different kinds of segment are not too disparate, it is further shown that $(\Delta G)_{T,p} = kT(N_A \ln \phi_A + N_B \ln \phi_B) + E^c d_{AB} \phi_A \phi_B$, where E^c is the intermolecular energy of the solution and d_{AB} is a constant defined in terms of the interaction potentials between the different kinds of segment. It is shown that equations arrived at by previous workers using the quasi-crystalline model do not depend on such restrictive assumptions, but merely require that the molecules shall be sufficiently long. A theoretical interpretation has been given of Brønsted's principle of congruent mixtures, and the following generalization of this principle is proposed. If two mixtures both containing chain molecules, are such that these molecules can be divided into identical sets of fragments by cutting the chains in suitable places, then these mixtures will have identical equations of state and identical solvent properties. The available evidence, in particular that reported by Koefoed in this discussion, supports this generalization with high accuracy. A.

532.73

10864. Statistical thermodynamics of solutions of molecules with spherical field of forces. I. PRIGOGINE AND A. BELLEMANS. *Disc. Faraday Soc., No.* 15, 80–93 (1953).

The cell model for solutions, used by one of the authors (I. P.) and his collaborators, is extended to mixtures of spherical molecules of slightly different radii. To take account of this difference, two characteristic distances a_A and a_B are introduced which are the mean distances of the first neighbours of a molecule A and of a molecule B. These distances are fixed by a condition of minimum free energy. The thermodynamic excess functions for the solution (excess free energy, energy, entropy and volume) are expressed in terms of purely molecular data. A.

532.73

10865. Statistical thermodynamics of *r*-mers and *r*-mer solutions. I. PRIGOGINE, N. TRAPPENIERS AND V. MATHOT. *Disc. Faraday Soc., No.* 15, 93–107 (1953).

The cell model of liquids is extended to apply to *r*-mer molecules. The treatment is based on the four main assumptions: (i) that the liquid can be represented by a quasi-crystalline lattice, (ii) that the elements of the *r*-mers are point-centres which interact according to the Lennard-Jones potential law, (iii) that the mean intermolecular field acting on each point-centre is harmonic and has spherical symmetry, (iv) that all displacements are small. The resulting equation of state expresses a principle of corresponding states for *r*-mer liquids. The extension of the treatment to a monomer + *r*-mer solution makes it possible to study the excess properties of the solution which result from the changes in the mean field caused by mixing. Explicit formulae are given for the excess volume, entropy and internal energy; the importance of the new effects is briefly discussed. A.

532.73

10866. Chemical statics of the methyl halides in water. D. N. GLEW AND E. A. MOELWYN-HUGHES. *Disc. Faraday Soc., No.* 15, 150–61 (1953).

The distribution of the methyl halides between water and the vapour state has been measured at various temperatures and pressures, and their heats of dissolution as gases, liquids and crystalline hydrates have been evaluated. The data have been discussed in kinetic and thermodynamic terms, and certain inferences are drawn concerning the nature and number of the water molecules which surround a polar solute molecule in aqueous solution. A.

532.73

10867. Thermodynamic and other properties of solutions involving hydrogen bonding. A. G. MITCHELL AND W. F. K. WYNNE-JONES. *Disc. Faraday Soc., No.* 15, 161–8 (1953).

A comparison of the excess enthalpies, entropies and free energies of mixing of mixtures of alcohols and of hydrogen peroxide with water shows striking differences in behaviour. For the hydrogen peroxide + water system the values of all the thermodynamic functions are negative, while for the alcohol + water systems the negative enthalpies are outweighed by much greater entropy contributions which result in positive excess free energies. The partial molal volumes also show differences in behaviour which are ascribed to the interaction between the structures of the two constituents of the mixtures. Basicity data also show a marked contrast in the behaviour of the two types of mixture which is in general agreement with that deduced from the thermodynamic data. A.

532.73

10868. Theory of upper and lower critical solution temperatures. J. A. BARKER AND W. FOCK. *Disc. Faraday Soc., No.* 15, 188–95 (1953).

The phase separation behaviour of a number of models in which the molecular interactions depend on relative orientation is investigated. One model shows upper and lower critical solution temperatures in the manner of the nicotine + water system. Another shows the kind of behaviour observed with partially miscible solids in which compound formation occurs. A third, representing a mixture of two hydroxy-compounds, shows only an upper critical solution temperature. A.

532.73

10869. A forgotten theory: the "negative saturation curve." J. TIMMERMANS AND J. LEWIN. *Disc. Faraday Soc., No.* 15, 195–201 (1953).

In accord with van der Waals's theory, the name *type du retrait complet* is given to systems having two critical solution points and a closed saturation curve. For such systems there is a volume contraction when the components are mixed and the immiscibility surface "recedes" with increasing pressure and eventually disappears: the two components therefore become miscible, if sufficient pressure is applied. In mixtures of this class one component is usually water, heavy water or glycerine, and the second component an organic compound taken from the middle of a homologous series; if a lower homologue is taken, the components become miscible at atmospheric pressure, but the mixture displays all the anomalies usually observed in the neighbourhood of a critical point. It would therefore be possible to study the saturation curve only using a negative pressure, and a possibility is pointed out of evaluating the magnitude of the required negative pressure by making use of a third component which displaces the saturation curve so that it appears at ordinary pressures. The theory is useful in explaining many apparent anomalies to be found with such common systems as aqueous solutions of the lower alcohols, acetone, pyridine, etc. A.

532.73 : 530.162

10870. The statistical mechanical basis of the Debye–Hückel theory of strong electrolytes. J. G. Kirkwood and J. C. Poirier. *J. phys. Chem.*, **58**, 591–6 (*Aug.*, 1954).

The potentials of mean force of sets of n ions, averaged over the configuration space of all other ions in the system, are expanded as power series in a charging parameter ξ. Equations are derived relating coefficients of the various powers of ξ in these expansions, using the method of semi-invariants. The validity of the linearized Poisson–Boltzmann equation for the coefficient of the first power of ξ in the expansion of the potential of mean force of an ion pair, when ion size is neglected, is demonstrated. The validity of the Debye–Hückel limiting law is thus shown in an unambiguous way. A systematic procedure of obtaining the coefficients of higher powers of ξ is outlined. When ion size is considered, the linearized integral equation for the potential of average force of a pair of ions possesses oscillating solutions at high ionic strength, corresponding to stratifications of average space charge of alternating sign in the neighbourhood of each ion. A.

532.73 : 536.632 : 536.7

10871. The heat capacities and other thermodynamic properties of some binary liquid mixtures. L. A. K. Staveley, K. R. Hart and W. I. Tupman. *Disc. Faraday Soc.*, *No.* 15, 130–42 (1953).

Measurements have been made of the heat capacity C_p, the coefficient of expansion α, and the adiabatic compressibility β_S at atmospheric pressure, of pure liquids and representative types of binary liquid system. For the pure liquids, the measurements have extended from room temperature to almost the boiling-point. And for each binary system three or four mixtures have been studied from room temperature to almost the boiling-point of the more volatile component. The results have been used to derive values of C_v for the pure liquids and mixtures. The variation of C_v with temperature for the pure liquids is examined from the point of view of the division of this quantity into a configurational term and terms due to the thermal energy. The deviations from ideality of the C_v values for the mixtures are then considered on this basis, and conclusions drawn about the molecular motion and inter-molecular association in these mixtures. A.

532.73 : 534.23

10872. Ultrasonic absorption in binary liquid systems near the critical solution temperature. G. F. Alfrey and W. G. Schneider. *Disc. Faraday Soc.*, *No.* 15, 218–25 (1953).

The present work is an investigation of the nature of the anomalous high acoustic attenuation in the region of the critical solution temperature of binary liquid systems reported earlier. An absolute measure of the attenuation near the lower critical temperature of the triethylamine + water system and near the upper critical temperature in the nitrobenzene + hexane system was obtained in the frequency range from 1 Mc/s to 9 Mc/s by employing an ultrasonic pulse technique. Although the viscosity shows a marked increase in the region of the critical temperature, it is found that the viscosity absorption is far too small to explain the observed absorption. The latter was found to show an almost linear frequency dependence and hence a large attenuation due to scattering appears improbable. The results are interpreted in terms of a relaxation mechanism. A.

MECHANICS OF GASES 533

533.15

10873. Temperature dependence of the thermal diffusion ratio. E. M. Holleran. Letter in *J. chem. Phys.*, **21**, 1901 (*Oct.*, 1953).

533.15

10874. Study of diffusion in polymers. S. N. Zhurkov and G. Ya. Rȳskiĭ. *Zh. tekh. Fiz.*, **24**, *No.* 5, 797–810 (1954) *In Russian.*

The theory and practice of a method for determining the diffusion coeff. of vapours of water and organic substances into high polymers, involving the measurement of the increase in weight of a film of the material exposed to the vapour, with a quartz spiral spring balance, is described. Investigations on the diffusion of water, methyl and ethyl alcohols, methylene chloride, ethyl bromide, chloroform and benzene into polystyrene, ethyl- and methyl-methacrylates are reported. Plots of ln D against $1/T$ yield 2 straight lines, intersecting at the solidification temperature of the polymer, T_g, indicating that the diffusion coeff. can be represented by the usual exponential form $D = D_0 \exp(-E/RT)$: D_0 and E are in all cases smaller below than above T_g. Above T_g, the rate of diffusion is given approx. by $E = E_0(1 + \alpha V)$ where E_0 and α are constants, and V is the molecular volume. R. C. MURRAY

533.15

10875. Transient flow of non-ideal gases in porous solids—one-dimensional case. J. S. Aronofsky and O. D. Ferris. *J. appl. Phys.*, **25**, 1289–93 (*Oct.*, 1954).

Calculations of pressure and production histories are presented for one-dimensional flow of non-ideal gases through porous media. The non-ideal properties considered in this paper are the gas viscosity and deviation factor (compressibility factor) which are assumed to vary as simple functions of pressure. The effect of each of these parameters is investigated independently as well as in combination. The results demonstrate that pressure declines and production histories in linear gas-flow systems are markedly influenced by variations in these parameters. Numerical solutions of the flow equations were obtained by solving the corresponding difference equations on an electronic digital computer. A.

533.16

10876. Measurement of viscosities of gases at high pressure. II. Viscosities of nitrogen and mixtures of nitrogen and hydrogen. H. Iwasaki. *Sci. Rep. Res. Insts Tôhoku Univ. A*, **6**, 296–307 (*June*, 1954).

For Pt I, see Abstr. 3926 (1953). Measurements of the viscosities of nitrogen, 80·4% N_2–19·6% H_2 system and 31·9% N_2–68·1% H_2 system have been made within about 1%, using the modified oscillating disk method, at the following conditions: pure nitrogen at 25°, 100° and 150°c up to 200 atm;

$80{\cdot}4\%\ N_2$–$19{\cdot}6\%\ H_2$ system at 50° and 100°c up to 200 atm; and $31{\cdot}9\%\ N_2$–$68{\cdot}1\%\ H_2$ system at 50°c up to 200 atm and at 100°c up to 100 atm. From these measurements it was found that $(\partial\eta/\partial\theta)_p$ is positive while $(\partial\eta/\partial p)_\theta$ becomes progressively smaller as the temperature increases and that $(\partial\eta/\partial\theta)_\rho$ is positive, remains constant over the whole density ranges within the limits of the experimental accuracy and is a function of the temperature alone. The experimental equations for viscosity-density isotherms were derived using the measured values. These equations reproduce them within the experimental accuracy. Calculating from the measured values, it was found that the deviations $[\Delta_{(\eta)}]$ of the viscosities of binary mixtures (η_m) from those $(n_N\eta_N + n_H\eta_H)$ made equal to the molal average of the viscosities of the components of the mixture are independent of the pressure within the experimental accuracy over the whole measured ranges and are functions of the temperature and the concentration ratio of components. A.

533.16

10877. The viscosity of isotopic substances. J. A. Pople. Letter in *Physica*, **19**, 668 (*July*, 1953). See Abstr. 8272 (1953).

533.24

10878. A fractionating converter for producing *para* hydrogen. W. F. Giauque. *Rev. sci. Instrum.*, **25**, 886–7 (*Sept.*, 1954).

A fractionating catalytic convertor is described. The purpose of the fractionating column is to permit the use of a partial convertor in the main liquefier stream at temperatures in the range of liquid nitrogen and yet avoid the possibility of back conversion of return gas from the pure para region at lower temperatures. A.

533.5

10879. Distribution of concentration of gas being pumped out in an oil diffusion vacuum pump. K. A. Savinskiĭ. *Zh. tekh. Fiz.*, **24**, *No.* 5, 875–8 (1954) *In Russian.*

Measurements with argon show that the concentration of gas being pumped out by an oil diffusion pump is a minimum close to the vapour-condensing wall, and not a maximum as claimed by Livshits and Rozentsveig [Abstr. 5899 (1953)]. R. C. MURRAY

533.5

10880. The formation of adsorbed layers in vacuum chambers and their detection by electrons. H. Koenig. *Vacuum*, 3, 3–10 (*Jan.*, 1953; publ. *Aug.*, 1954).

Adsorption phenomena in evacuated vessels are investigated. Adsorbed layers of gas are evident in metal vacuum apparatus and Drechsler and Hess have shown that the speed of their growth can serve as a measure of the quality of an operational vacuum. The nature and properties of adsorbed layers are discussed with particular reference to conditions in the electron microscope and diffraction camera. Adsorbed layers normally originate from water vapour and hydrocarbons present in the residual atmosphere, the latter as a result of the use of greased joints or rubber seals in the construction of plant. A.

533.5

10881. Cold cathode ionisation gauges for the measurement of low pressures. G. K. T. Conn and H. N. Daglish. *Vacuum*, **3**, 24–34 (*Jan.*, 1953; publ. *Aug.*, 1954).

Cold cathode ionization gauges in which the discharge is maintained in an axial magnetic field provide a convenient and rapid means of measuring pressure in the range 10^{-2} to 10^{-7} mm Hg. These instruments are simple to make and operate and it is virtually impossible to damage them. With such a gauge, measurement of pressure is effected by a robust pivotmeter which measures a current of ions formed by electron bombardment. Primary electrons are released by cold emission from a pair of cathodes and many secondary electrons are generated by the ions themselves. The magnetic field causes the electrons to move in tight spirals to and from between the two cathode plates. In this way the number of ions per electron, between initial emission and eventual escape from the discharge to the anode, is much increased. A review is given of the construction, characteristics and performance of various types of cold cathode gauge. The influence is reported of size and shape of the electrodes, of applied voltage, of magnetic field and of the nature of the gas. Reference is made to the performance at relatively high pressures (10^{-2} to 10^{-3} mm Hg). Attention is drawn to the generation of radio frequencies by cold cathode gauges. A.

533.5

10882. Application of a tracer to cathode-gettering and gas-adsorption problems. F. de Boer and W. F. Niklas. Letter in *Brit. J. appl. Phys.*, **5**, 341–2 (*Sept.*, 1954).

The radioactive isotope C^{14} was introduced into cathode-ray tubes which were then subjected to a carefully controlled processing. The activities of the cathode and stainless steel electrodes of two types of alloy were measured after breaking open. The final results for specific gettering power per unit surface area were: (BaSr)O cathode, 51·00; Ti-stabilized stainless steel, 0·48; nickel-chrome stainless steel, 0·11. A. H. W. BECK

533.5

10883. The experimental determination of the speed of a vacuum pump and of components of a vacuum system. C. W. Oatley. *Brit. J. appl. Phys.*, **5**, 358–62 (*Oct.*, 1954).

Describes a method of measuring the speed of a vacuum pump which appears to have many advantages over existing methods. It can be used at pressures down to at least 10^{-4} mm and is independent of the absolute accuracy of the calibration of the gauge used to measure these pressures. By an extension of the method it becomes possible to measure the resistance to the flow of rarefied gas of any tube or other channel of which a small-scale model can be made. Results are given for right-angle bends, T-pieces and other components which are likely to be used in the construction of a complete vacuum system. A.

533.5 : 621.375.232

10884. Some remarks on the electronic circuits for a leak detector. J. Lecomte, J. Taieb and J. Thebault. *Vide*, **8**, 1422–7 (*Nov.*, 1953).

The leak detector is of the mass-spectrometer type. For abstract see Abstr. 4739 B (1954).

533.5 : 621.385.032.46

10885. The use of getters for the production of very high vacua. S. Wagener. *Vacuum*, **3**, 4–23 (*Jan.*, 1953; publ. *Aug.*, 1954).

For previous part see Abstr. 4958 (1952). The pressure in a sealed-off tube can be determined from two rate values, the rate at which gas is evolved from the tube components, and the rate at which this gas is taken up by the getter. Therefore knowledge of the gettering process should be combined with information on gas evolution. A brief survey is given, showing *inter alia* that carbon oxides constitute a major part of the gases evolving in electronic tubes. Concerning the gettering process. the reaction between Ba and CO is investigated in detail. During exposure to CO the gettering rate decays rapidly from a few 1./sec to very near zero. This decay which is not indicated by a change in appearance of the getter makes the getter inefficient for other gases as well. The decay is thought to be due to formation of a protective surface film whose molecular volume is larger than the atomic volume of barium. The influence of flashing conditions and getter temperature on the decay is studied. It is shown that the gettering of CO is irreversible between room temperature and 300°c. A new property of getters made of thorium powder and similar materials is discussed. Such materials can be used as "selective getters" which remove oxidizing gases from the valve atmosphere but establish a constant pressure of hydrogen which can be controlled by varying the temperature of the getter and the quantity of hydrogen dissolved in it. Experimental evidence shows that such a hydrogen atmosphere at pressures of 10^{-7} to 10^{-6} mm Hg reduces the interface resistance of oxide cathodes by a factor 10. A.

533.583

10886. Influence of electronic impact on the rate of sorption of gases on to getter materials. S. Wagener. Letter in *Nature* [*London*] **173**, 684–5 (*April* 10, 1954).

The author has used his flow method for measuring getter rates [Abstr. 4958 (1952)] with a Knudsen gauge to demonstrate that, contrary to expectation, the gettering rate of Ba at pressures of 10^{-6} to 10^{-7} mm Hg is not influenced by electron impacts. The activation energy for the sorption of O_2 on Ba is $> 0\cdot05$ kcal/mole compared with 5–8 kcal/mole at higher pressures. A. H. W. BECK

533.6.01

10887. The American wind turbine. R. H. Nilberg. *Canad. J. Phys.*, **32**, 639–52 (*Oct.*, 1954).

The windmill theory published by A. Betz of Göttingen does not take into account the rotational motion of the air stream behind the mill, which is quite large behind the low-speed multiblade "American wind turbine." This paper presents a theory of the low-speed wind turbine showing that the shape of the airfoil blade is predetermined by the theoretical deflection of the air stream and should not be chosen arbitrarily. An increase of starting torque and efficiency of about 20% may be expected. A.

533.6.011 : 534.222.2

10888. An experimental investigation of the interaction of a shock wave with a subsonic stream bounded by a wall. D. W. Holder, A. Chinneck and G. E. Gadd. *Phil. Mag.*, **45**, 997–1009 (*Oct.*, 1954).

An experimental study has been made of a model of a boundary layer consisting of a subsonic stream bounded on one side by a wall and on the other by a supersonic main stream. The subsonic stream was approximately uniform at the point where it first met the main stream, but it became progressively less uniform downstream of this point because of mixing with the main stream and the growth of the boundary layer at the wall. Particular attention is given to the pressure rise which takes place at the wall when a wedge is attached to it. It is found that the pressure begins to rise ahead of the apex of the wedge, and that the magnitude of this upstream effect increases as the Mach number of the secondary stream is reduced. A comparison between the measured values of the upstream effect, and the values predicted by a theory which has been advanced by Lighthill, shows reasonable agreement. A.

MOLECULAR THEORY OF GASES 533.7

533.7

10889. Measurements of thermomolecular pressure differences on argon and nitrogen. J. M. Los and R. R. Fergusson. *Trans Faraday Soc.*, **48**, 730–8 (*Aug.*, 1952).

The theory of thermomolecular pressure differences in the form introduced by Weber is applied to measurements on argon and nitrogen. The integration of the fundamental differential equation for the pressure gradient is expanded to give two forms of solution. The experimental data for argon are found to fit one form and the experimental data for nitrogen the other. The equations obtained enable the thermomolecular pressure differences to be calculated for all values of pressure, temperature and tube radius. Values so calculated fit the experimental data for three glass capillaries with a maximum uncertainty of 1 micron. In a metal capillary examined the deviations were less than 2·5 microns. Reasons for the larger discrepancy between theory and experiment for the metal capillary are sought. For argon an increase of Maxwell's reflection coefficient was found in the temperature region in which considerable adsorption takes place. A.

533.7

10890. The influence of molecular transformations on transport phenomena. J. E. Verschaffelt. *Bull. Acad. Roy. Belgique Cl. Sci.*, **39**, *No.* 3, 257–72 (1953) *In French.*

533.7

10891. Association in polar vapours and binary vapour mixtures. J. D. Lambert. *Disc. Faraday Soc.*, *No.* 15, 226–33 (1953).

The problem of finding equations of state for polar vapours and their binary mixtures is discussed. The second virial coefficients of these vapours show systematic deviations from the principle of corresponding states, which may be interpreted in terms of the hypothesis that they undergo partial association due to dipole interaction or hydrogen bonding. This hypothesis is shown to give consistent quantitative results when applied both to pure polar vapours and to simple types of binary mixture. A.

533.7 : 536.71

10892. The transport properties and equation of state of gaseous mixtures of the helium isotopes. E. G. D. Cohen, M. J. Offerhaus and J. de Boer. *Physica*, **20**, 501–15 (*Aug.*, 1954).

On the basis of the 12–6-Lennard-Jones potential field, used in previous publications to describe the properties of the pure gases He^3 and He^4, a quantum mechanical calculation has been made of the properties of gaseous mixtures of He^3 and He^4: (1) The self-diffusion coefficient and the mutual diffusion coefficient in first and second approximation; (2) the viscosity and the heat conductivity of mixtures of He^3 and He^4; (3) the thermal diffusion ratio k_T; (4) the second virial coefficient of mixtures of He^3 and He^4. The theoretical data for the viscosity o mixtures of He^3 and He^4 show a satisfactory agreement with recent measurements made by Van Itterbeek *et al.* (1953) and Becker *et al.* (1954). Measurement of the thermal diffusion would be a very sensitive test of the present calculations. A.

533.7 : 539.13

10893. Solubility in compressed gases. S. Robin and B. Vodar. *Disc. Faraday Soc., No.* 15, 233–8 (1953).

The authors' experimental results on the solubility of phenanthrene, as well as various data of other authors, have been interpreted with the help of an equation of state limited to the 2nd virial coefficient. The agreement between experimental values and theory is reasonable, and the determination of the force constants of the Lennard-Jones potential is possible. A.

533.7 : 539.13

10894. The solubility of solids in gases. A. H. Ewald, W. B. Jepson and J. S. Rowlinson. *Disc. Faraday Soc., No.* 15, 238–43 (1953).

The solubility of a solid in a compressed gas is usually greater than the concentration which corresponds to its normal vapour pressure. This excess solubility may be expressed in terms of a virial expansion in which the successive coefficients represent the clustering of single gas molecules, pairs of gas molecules, etc., around one molecule of solute. If the molecules are non-polar, the second virial coefficient of such a system can be calculated from the properties of the pure substances and the principle of corresponding states. The higher coefficients may be calculated from an approximate extension of this law. Theoretical solubilities, calculated in this way, are compared with recent measurements of solubilities in compressed air and ethylene. A.

533.75

10895. The virial coefficients of a gas mixture. J. S. Rowlinson, F. H. Sumner and J. R. Sutton. *Trans Faraday Soc.*, **50**, 1–8 (*Jan.*, 1954).

A simple expression is proposed for calculating the virial coefficients of a gas mixture from those of the pure components. A third virial coefficient is computed numerically and compared with this and with two other approximations which, on the whole, are not as satisfactory. Approximate values of this third virial coefficient, which were used earlier in interpreting the solubility of a solid in a compressed gas, are very close to values computed directly and so need no revision. A.

533.75

10896. The virial series of the ideal Bose–Einstein gas. B. Widom. *Phys. Rev.*, **96**, 16–17 (*Oct.* 1, 1954).

It is suggested that the ideal Bose–Einstein gas be used as the prototype of an imperfect gas in investigating a possible connection between divergence of the virial series and the condensation phenomenon. An explicit expression is obtained for the virial coefficients in this case. Obtaining the radius of convergence of this series appears to be a formidable mathematical problem, and only a lower bound for this radius is established. It is conjectured, however, that the radius of convergence is infinite. A.

VIBRATIONS . ACOUSTICS 534

534.121

10897. Thickness-shear and flexural vibrations of a circular disk. R. D. Mindlin and H. Deresiewicz. *J. appl. Phys.*, **25**, 1329–32 (*Oct.*, 1954).

Equations governing the coupled thickness-shear and flexural vibrations of isotropic, elastic plates are solved for the case of a circular disk with free edges. The results of computations are given for the resonant frequencies analogous to those which would be excited in an AT-cut quartz disk with full electrode coating. A marked difference is observed between the frequency spectrum of the disk and the spectrum of cylindrical vibrations of a rectangular plate. The difference is due to the presence of thickness-twist modes of motion, in the disk, which, along with the thickness-shear modes, are coupled to the flexural modes. A.

534.22

10898. Velocity of one megacycle ultrasonic waves in benzene and toluene solutions of polystyrene. W. M. Fox and G. W. Hazzard. *J. chem. Phys.*, **22**, 1485–8 (*Sept.*, 1954).

A standing wave, single crystal interferometer was used to measure the ultrasonic velocity in polystyrene having molecular weights from 4100 to 159 000. Most of the measurements were made with 2 g of polystyrene per 100 cm^3 of solution, benzene being the solvent. Some measurements used similar concentrations with toluene as the solvent. In the range of temperatures from 8·95°c to 54·45°c the velocity attributable to the polystyrene had a negative temperature coefficient below 35°c and a positive one above 35°c. At a given temperature the velocity attributable to the polystyrene showed two minima when plotted as a function of molecular weight. These minima occurred at polystyrene molecular weights of 17 000 and 53 000. Suggestions, but no conclusions, are given for the cause of these minima or dispersive regions. A.

534.22

10899. Temperature dependence of ultrasonic velocity in plastics. S. V. Subrahmanyam. *J. chem. Phys.*, **22**, 1562–3 (*Sept.*, 1954).

The composite piezoelectric oscillator method has been employed to study the temperature dependence of the velocity of ultrasonic waves in Perspex and polystyrene plastics. While confirming a previously reported transition in Perspex at 60°c, the results show the existence of a transition in polystyrene also at 70°c for the first time. A.

534.222.2

10900. Note on the propagation of explosion-produced air shocks. M. Birk, Y. Manheimer and G. Nahmani. Letter in *J. appl. Phys.*, 1208 (*Sept.*, 1954).

Experimental results support Lin's theory [see Abstr. 2125 (1954)] of the propagation of cylindrical shock waves produced by the instantaneous release of energy along an infinite straight line, and its conclusion that the reciprocal shock velocity is a linear function of the square root of the time since the moment of energy release. The experiments are confined to the range of Mach numbers 7–14. J. S. G. THOMAS

534.23

10901. The transmission of sound by spherical shells. A. Bergassoli, F. Canac and T. Vogel. *Acustica*, **4**, 403–6 (1954) *In French.*

The acoustical insulation of spherical shells has been found to be appreciably greater than that of plane disks in the lower frequency range. This result is accounted for in a theoretical discussion of the natural frequencies of the shell, under the assumption of extensional vibrations. A.

534.23

10902. Thermal relaxation in gases. R. Brout. *J. chem. Phys.*, **22**, 1500–2 (*Sept.*, 1954).

The solution of the linearized equations appropriate for sound dispersion is presented. The limiting cases as the sound frequency becomes large or small is examined. The two-state gas is exhibited as a special case and shown equivalent to previous work in the field when the appropriate assumptions are made. A.

534.232

10903. Some remarks on the analysis of magnetostrictive transducers. H. Nødtvedt. *Acustica*, **4**, 432–8 (1954).

The electro-mechanical coupling constant of magnetostrictive vibrating rods is calculated from basic physical constants. The formula given is valid for both fundamental and higher harmonics. The calculated values are compared with directly measured coupling constants. Next, the electric analogue of rods is given, and it is shown how a graphical analysis of admittance and impedance diagrams gives convenient rules for evaluating the relevant quality factors. Actual measurements on a particular specimen are included. A.

534.374

10904. A new method of computing acoustical filters. W. K. R. Lippert. *Acustica*, **4**, 411–20 (1954).

A new method of computing the sound reflection and transmission of acoustical filters which does not depend on the image parameter theory is presented. The transmitted and reflected sound pressure propagating along a duct with *n* equal filter sections connected in cascade is represented by the characteristic factors of one section which consists of a so-called symmetrical discontinuity with a duct piece of arbitrary length connected to the input and output. In loss-free cases the sound transmission and reflection can be found with the aid of diagrams. It is shown how the new method differs from the image parameter theory and that it is superior in cases of a small number of practically loss-free filter sections which are terminated by a non-reflecting duct system. The sound reflection and transmission of a filter with a reflecting output duct can be easily derived from the fundamental case with a non-reflecting terminal and this method can also be applied to filters that are terminated by non-equal sections. A.

534.39

10905. Radiation pressure in fluids. J. Mercier. *Acustica*, **4**, 441–6 (1954) *In French.*

An account of the different ways of considering radiation pressure and of calculating it. Is it a scalar or vectorial quantity? The author introduces a "radiation vector" equal to the product of excess pressure and velocity of displacement of a section of a plane wave and calculates the pressure of radiation on an obstacle, considering incident and reflected waves separately. He extends his calculation to the case of progressive plane waves in an absorbent medium and to that of spherical waves. A.

534.441.2 : 621.395.625.3

10906. The use of sound recording for the analysis of transients. H. Briner. *Onde élect.*, **34**, 200–3 (*March*, 1954) *In French.*

In order to obtain an accurate frequency and amplitude analysis of transient acoustic phenomena, a method is suggested in which the sound transient is recorded by some means, such as magnetic or optical recording on an endless tape, permitting repetition, as often as required, of successive subdivisions of the transient, the subdivisions preferably having a duration of the order of 0·01 sec. Details of the proposed method, such as the use of magnetic powder on the surface of a cylinder capable of rotation at different speeds for recording transients of different types, are discussed. Electronic methods enable the frequency spectra of the successive subdivisions of the particular sound transient under examination to be displayed on the screen of a c.r.o. A. WILKINSON (R)

534.7 : 612.85

Physiological acoustics. Hearing. *See Abstr.* 11687

534.83

10907. Noise levels underneath some civilian aircraft shortly after take-off. P. H. Parkin and H. J. Purkis. *Acustica*, **4**, 439–40 (1954).

The maximum sound pressure levels (in octave bands) have been measured underneath several types of civilian aircraft shortly after take-off. The height of the aircraft varied from 15–90 m; the results have been corrected to a standard height of 38 m. A.

534.844

10908. The acceptability of artificial echoes with reverberant speech and music. A. F. B. Nickson, R. W. Muncey and P. Dubout. *Acustica*, **4**, 447–50 (1954).

Groups of subjects seated in a room of short reverberation time (0·15 sec) assessed whether or not a single artificial echo added to speech or music was disturbing. The artificial echo varied 50 dB in intensity level and up to 600 msec in delay. The acceptable-echo-level/delay relation is shown to consist of three parts; the initial period when the Haas effect is prominent, an interim period determined by the decay time of the sound type and a final period when the level of acceptable echo scarcely changes with the delay, being determined by the dynamic range of the programme material. A.

534.862.3/.4

10909. The recording characteristics of disks. P. Gilotaux. *Onde élect.*, **34**, 257–9 (*March*, 1954) *In French.*

Experience shows that the response characteristics of disks vary to a greater degree than can be accounted for by the usual recording-characteristic tolerances. The cause is partly subjective, e.g. the conditions under which playback is carried out, and partly objective, e.g. the type of loudspeaker or pick-up employed. To mitigate these differences, the use of a linear amplifier with separate top and bass tone controls is recommended. H. G. M. SPRATT

534.862.3

10910. Main characteristics of the sound track of a multi-layer colour film. A. I. Parfent'ev. *Zh. tekh. Fiz.*, **24**, *No.* 4, 667–76 (1954) *In Russian.*

The comparative characteristics of photographic sound tracks of black-white and coloured films obtained with multi-layer film material are considered. The influence of the spectral characteristics of the incandescent lamps and photoelements used for recording the tracks was investigated. The main shortcoming of the sound track on the colour film is the small modulation factor when the track is produced by a Cs–O photoelement. There is a great difference in the optimum conditions for the production of sound tracks on the silver-emulsions prepared for processing with Cs–O and Sb–O photoelements. Methods of obtaining really satisfactory sound tracks are indicated. B. F. KRAUS

534.862.3

10911. A study of the suspension of gramophone disk cutters and the cutting conditions as regards cutters for flexible disks. P. Meunier. *Onde élect.*, **34**, 260–4 (*March*, 1954) *In French.*

Maintenance of sufficiently constant depth of cut in the case of micro-groove flexible disks is extremely difficult. The "advancing ball" technique is inconvenient and is open to the risk of particles getting under the ball, while the normal design of pivoted arm with pressure adjusted by means of counterweights or a spring gives rise to mechanical oscillations. The equivalent relevant circuit of the latter device is shown and it is pointed out that neither friction damping nor the introduction of an anti-resonant circuit will cure the trouble. Instead, a double-lever system is proposed and an analysis of the equivalent circuit worked out. A sketch of one practical form of the design which has given satisfaction is shown and described. H. G. M. SPRATT

534.862.3 : 781.6

10912. The contribution of recording techniques in the building up of new musical matter and forms. Applications to concrete music [musique concrète]. J. Poullin. *Onde élect.*, **34**, 282–91 (*March*, 1954) *In French.*

A passage of music does not lend itself readily to exact analysis because of its fleeting character nor to graphical representation—since the three co-ordinates of time, pitch and level are always involved, the individual notes are usually complex, and subjective as well as objective values have to be considered. The subjective effects of frequency shift and change of level of both individual notes and musical passages are studied in some detail and two elaborate types of multi-track magnetic recording equipment, designed to further these studies, are described. The use of 4- or 5-track recordings to provide spacial or stereophonic effects is also discussed. It is claimed that musical composition will be enriched by this work. H. G. M. SPRATT

534.862.4 : 612.858.751

10913. Evolution of methods of reconstituting aural space. J.-W. Garrett. *Onde élect.*, **34**, 215–25 (*March*, 1954) *In French.*

The subjective factors involved in binaural and stereophonic listening are closely studied. The normally accepted methods of attempting to achieve either are reviewed and the virtual impossibility of effecting true stereophonic transmission and reproduction in certain cases pointed out. An alternative technique, termed "directed stereophony" and claimed to simulate true stereophony, is described. Each microphone channel is divided into two separate channels, a "left" and a "right-hand" channel and a differential fader potentiometer is included to increase the gain of one line as the other is attenuated. Branch circuits, whereby artificial echo effects can be introduced, are added. Set up at places of historical interest in France, the system is claimed to have produced results of an extremely high aesthetic level. H. G. M. SPRATT

OPTICS . RADIATION . SPECTRA

535.222

10914. A laboratory experiment on the velocity of light. C. H. Palmer, Jr and G. S. Spratt. *Amer. J. Phys.*, **22**, 481–5 (*Oct.*, 1954).

Apparatus is described which permits direct measurement of the velocity of light with about 1% error. The experiment is patterned after the precision method of Anderson using a Kerr cell and interferometer, but is much simplified. The optical parts used are of the kind usually available in small colleges, and the electronic components were built chiefly from war surplus material. The experiment is designed for undergraduate instruction with emphasis on simplicity rather than precision. A.

535.23.08–15 : 551.521.3

10915. An infrared detector for measurement of the back radiation from the sky. S. C. Stern and F. Schwartzmann. *J. Meteorol.*, **11**, 121–9 (*April*, 1954).

A long-wave radiometer is described in considerable detail. Physical and transmission characteristics of the hermispherical "windows" are presented, and calibration and use of the instrument are discussed. The results of a series of night-time and daytime measurements of the infrared emissions of the atmosphere are compared with theoretical values obtained from the Elsasser radiation diagram, and satisfactory agreement is found to exist. A.

535.231 : 551.524.7

10916. The cooling of a gas by radiation. E. Bauer and T.-Y. Wu. *Proc. Phys. Soc.* [*London*] *A*, **67**, 741–50 (*Sept.*, 1954).

A gas composed of atoms having two electronic states is considered. Transitions between these two states can take place by collisions, and by emission or absorption of radiation. When the radiative transition probabilities are small compared with those due to collisions, a "temperature" may be defined for the translational motion. The general problem is formulated for the case where the total concentration of the gas depends on the space co-ordinates in a given way, and the possibility of the "imprisonment" of the radiation emitted is taken into account. In this case the problem leads to a pair of coupled integro-differential equations, from which the "temperature" and the concentration of atoms in the excited state are obtained as functions of space and time. Neglecting the imprisonment of the resonance radiation and the spatial variation of the temperature, calculations are made for the case when the energy difference between the two states is of the order kT, for a number of values of the ratio between radiative and collisional transition probabilities. The results are applied to the problem of the cooling of the atmospheric gas at high altitudes (100 km) at night, as a result of the magnetic dipole transitions between the components of the ^3P state of the oxygen atom. A.

535.241 : 628.9

10917. Modern ideas on [photometric] nomenclature. D. E. Spencer. *Illum. Engng*, **49**, 394–400 (*Aug*, 1954).

Discusses the basic principles which should govern the choice of fundamental concepts in illuminating engineering and the terms used for them. The three recommended are (i) pharos (luminous flux), (ii) pharosage (illumination), (iii) helios (brightness, or luminance). The advantages of this system and the disadvantages of the current system are pointed out. See also Abstr. 5134 (1953), 202 (1954).

J. W. T. WALSH

535.242

10918. Peculiarities of visual photometry in the range of low brightness. A. A. Vol'kenshteĭn. *Zh. tekh. Fiz.*, **24**, *No.* 4, 622–36 (1954) *In Russian.*

The problem in practical photometry is often complicated by the difficulties introduced by colour differences of the light which become more accentuated in the low brightness range. It is impossible to refer photometric measurements at different wavelengths to each other without a more or less artificial standard for calibration, and the establishment of such a standard in itself has to take the spectral sensitivity of the eye into account. The latter is different for normal and very low light levels, as represented by two distinct "standard luminosity functions." Certain conditions have also to be observed in the establishment of optical equilibrium between the external and internal radiant fields to be compared, e.g. that the diameter of the exit pupil of the instrument must not be smaller than the diameter of the observer's pupil in dark adaptation (8 mm). Equivalent brightness curves *v.* standard luminance can be obtained for various colours if the curves of spectral transmission of the filters used and of the spectral absorption of the sources of light are available. The spectral transmission curves of the filters are used for obtaining their equivalent transmission coefficients. Owing to differences in the angular accommodation of the human eye to relative brightness differences, certain shapes and dimensions of the optical (photometrical) fields are also more favourable than others.

B. F. KRAUS

535.245 : 518.5

10919. Use of high speed computing devices in photometric calculations. G. A. Horton. *Illum. Engng*, **49**, 403–8 (*Aug.*, 1954).

Compares the time taken (*a*) by a technician with desk computing equipment and (*b*) by a card-programmed electronic calculator in carrying out the calculations needed to prepare from observed figures the standard form of photometric report on a street-lighting fitting. These times were respectively 15–20 man-hours and a little over one hour. Other applications of the calculator to photometric work are suggested. J. W. T. WALSH

535.247.1 : 518.5

10920. Simple device for reducing microphotometer traces to curves of intensity. J. D. Purcell. *J. Opt. Soc. Amer.*, **44**, 679–84 (*Sept.*, 1954).

A mechanical device is described that performs automatically the laborious task of reducing a microphotometer spectrum trace to a spectral intensity curve. In performing the conversion the microphotometer trace, divided into sections, is contact printed on to sensitized material using a narrow slit light source and moving the trace and photographic material at different rates of speed past the slit. The slit is parallel to the wavelength axis and, in effect, scans along the density axis. The photographic material moves at constant speed, while the motion of the trace is controlled by a cam whose shape is essentially the photographic characteristic curve. The density curve is converted to a curve of log intensity in one step, and a second step is used to convert to linear intensity. Other uses of the device are suggested. A.

535.247.4

10921. A filter photometer for use at sea. R. A. Cox. *J. sci. Instrum.*, **31**, 374–6 (*Oct.*, 1954).

The instrument is designed to determine the optical density of coloured solutions to an accuracy of $\pm 1\cdot 0\%$ under the severe conditions experienced in a ship at sea. It is suitable for the colorimetric analysis of nutrient salts in sea water, and works reliably at sea even in bad weather conditions. A new optical arrangement is used, with a movable lamp between two fixed photocells, and this gives a linear extinction scale. The electric circuit is designed for simplicity and reliability, and uses one double triode and a robust and relatively inexpensive meter. Typical calibration graphs show the accuracy to be within the permissible limits. A.

535.317

10922. The basic theory of varifocal lenses with linear movement and optical compensation. F. G. Back and H. Lowen. *J. Opt. Soc. Amer.*, **44**, 684–91 (*Sept.*, 1954).

The two main problems facing the designer of varifocal lens systems are compensation for image shift and correction of aberrations for each zoom position. Most designers have chosen the easy and obvious way of compensating for image shift by using mechanical nonlinear cams, gears and linkages, and have concentrated their efforts on aberrational correction only. The alternative is shift-compensation by optical means. A.

535.317.25 : 771.351

10923. Method for determining the resolving power of photographic lenses. F. E. Washer and I. C. Gardner. *Circ. Nat. Bur. Stand., No.* 533, 27 + ii *pp.* (1953).

This Circular provides the photographer with two sets of charts by which the resolving power of a photographic lens may be numerically measured with respect to a definite scale of values. A detailed description is given of the procedure and technique to be followed in order that comparable values may be obtained by different observers. The test provides an objective method of testing a photographic lens. The six charts of one set are printed in black ink on a white background to form a high-contrast chart. The six charts of the other set are printed with grey ink on a grey background to form a low-contrast chart. Additional uses of these charts are also described. These uses include the testing of goggle lenses for definition and prismatic power and the testing of telescopes and binoculars for definition. A.

535.317.5

10924. The problem of evaluating a white light image. R. E. Hopkins, S. Oxley and J. Eyer. *J. Opt. Soc. Amer.*, **44**, 692–8 (*Sept.*, 1954).

The authors have made investigations with Super XX film and find that the resolving power in white light is strongly influenced by the shape and size of the blue and red images. The results indicate that if the imaging characteristics of a lens in white light are to be determined photoelectrically they should be done in at least three wavelength regions. As a by-product of the experiments it was found that the low-contrast resolving power correlated fairly well with subjective picture evaluation. A.

535.317.6

10925. A toric skew ray trace. A. E. Murray. *J. Opt. Soc. Amer.*, **44**, 672–6 (*Sept.*, 1954).

A skew ray trace through a toric surface is presented, starting from the data of a ray incident on the optical axis in a plane forming an arbitrary angle with the meridional. With these data and the constructional parameters the refracted ray data are found in a series of equations. This trace can be readily generalized to accommodate the case of a ray incident on any point of the toric surface from any direction. A.

535.323

10926. Index of refraction of fused quartz glass for ultraviolet, visible, and infrared wavelengths. W. S. Rodney and R. J. Spindler. *J. Opt. Soc. Amer.*, **44**, 677–9 (*Sept.*, 1954).

This was determined for 24 wavelengths from $0{\cdot}34669$ to $3{\cdot}5078\ \mu$, using the minimum deviation method. The whole range was covered with a single instrument. The variation in index between samples was determined and no definite variations in dispersion were observed. Possible relations between purity and index are discussed. A.

535.323 : 535.345

10927. Optical constants of boron in visible and near infra-red. N. Morita. *J. Sci. Res. Inst.* [*Tokyo*] **48**, 8–12 (*March*, 1954).

Thin films of boron were prepared by vacuum deposition on fused quartz plates. Optical transmission and reflection were measured as functions of wavelength in visible and near infrared, and the values of optical constants in this region were obtained from the theoretical transmission and reflection equations. The index of refraction was $1{\cdot}9$ at $\lambda = 0{\cdot}45\ \mu$ and increased to $3{\cdot}7$ at $\lambda = 2{\cdot}4\ \mu$. The absorption constant, rising steeply at $1\ \mu$, attained $1{\cdot}8 \times 10^5\ \text{cm}^{-1}$ at $\lambda = 0{\cdot}45\ \mu$, and the threshold of optical absorption band was shown to be $1\ \mu$ or $1{\cdot}2$ eV. A.

535.323 : 535.345

10928. Optical properties of lead telluride. M. E. Lasser and H. Levinstein. *Phys. Rev.*, **96**, 47–52 (*Oct.* 1, 1954).

Optical constants of lead telluride films as a function of both temperature and oxygen content have been investigated. The films were evaporated on to sapphire disks subsequently exposed to air and also on sapphire disks maintained at pressures lower than 10^{-6} mm of Hg. Film thickness, determined by Tolansky interference techniques and by weighing techniques, indicated that the density of evaporated layers of PbTe is about 10% smaller than for bulk. The optical constants were calculated from the reflection and transmission curves of the film. The addition of oxygen to the film was shown to give rise to an increase in absorption and a slight increase in the index of refraction. The optical properties were then shown to be strongly dependent on the temperature of the film. A mechanism has been proposed to explain the results. A.

535.33.07 : 535.339–31

10929. Ultraviolet double monochromator for biological use. H. Wihlm. *Rev. Opt.*, **33**, 425–54 (*Sept.*, 1954) *In French.*

It is shown how the photometric and optical features of a monochromator can be theoretically determined. The effects of aberrations on the spectral purity of the radiation can be calculated easily by an analytic method. Experimental results confirm the theory. A.

535.33.07 : 535.421

10930. Performance of Merton-N.P.L. gratings in a commercial infrared spectrometer. A. R. H. Cole. *J. Opt. Soc. Amer.*, **44**, 741–3 (*Sept.*, 1954).

Spectra are given to illustrate the performance of echelette gratings made by the Merton-N.P.L. process, when used in a commercial spectrometer. The necessary instrumental modifications are described, and it is shown that one of these gratings, suitably blazed, can be used to cover the range 2·5–15 μ with resolution greatly in excess of prisms of lithium fluoride, calcium fluoride and sodium chloride, and at less than 5% of the combined cost of these prisms. A.

535.33.07 : 535.65

10931. A photoelectric spectrophotometer and tristimulus colorimeter designed for teaching and research. W. D. Wright. *Optica Acta*, **1**, 102–7 (*Sept.*, 1954).

The instrument consists of a large double monochromator in which the light, after dispersion through the upper halves of two 60° dense flint prisms, is focused to produce a spectrum some 25 cm long. A mirror strip located in the plane of the spectrum selects the required waveband and reflects it back through the lower half of the dispersing system. The return beam is then reflected by a prism and brought to a slit focus in the plane of the exit-slit. The spectral purity of the light emerging from the slit is primarily determined by the width of mirror used in the spectrum, and several sizes of mirror are provided. The colour filter or surface whose spectral transmission or reflection curve is to be measured is mounted in a holder beyond the exit-slit and provision is made to rotate the specimen to provide various angles of incidence of illumination. A G.E.C. Universal Precision Photoelectric Photometer Unit is used to measure the light flux from the specimen, and the photocell can be moved on a radius around the specimen to permit polar curves of reflection and transmission to be measured if desired. The instrument can be adapted as a tristimulus colorimeter by mounting a 25 cm strip of concave mirror in the plane of the spectrum to reflect and re-unite the whole of the spectrum on its return passage through the dispersing system. Templates can then be placed in front of the mirror of such a shape that, in conjunction with the spectral sensitivity of the photocell, the whole system has a spectral sensitivity corresponding to the x, y, or z distribution curve of the C.I.E. trichromatic system of colour measurement. Comparison of the photocell readings with the sample and the reference standard illuminated in turn, for each of the templates, provides a direct determination of the tristimulus values of the sample. Polar curves of chromaticity can also be measured. A.

535.33.08

10932. A new method for the production of active nitrogen and its application to the study of collision effects in the nitrogen molecular spectrum. C. R. Stanley. *Proc. Phys. Soc.* [*London*] *A*, **67**, 821–7 (*Sept.*, 1954).

The source described employs a high tension arc and can operate at comparatively high pressures. The afterglow spectrum is that of the Lewis–Rayleigh glow at low pressures, but is modified at the higher pressures. Reasons are given for interpreting this modification as due to exchanges of vibrational energy occurring in collisions between nitrogen molecules. A modification is made to Mitra's theory of active nitrogen. A.

535.338

10933. Bacher and Goudsmit theory of complex spectra. R. E. Trees. *J. Res. Nat. Bur. Stand.*, **53**, 35–48 (*July*, 1954).

The Bacher and Goudsmit theory (1934) expresses the energy of a state of an atom in terms of a linear combination of energies of states of other ions of the same atom. This theory is tested in the spectra with *d*- and *s*-electrons and general conclusions drawn about its accuracy. In deriving their theory, Bacher and Goudsmit formally introduced many-particle interactions. They showed (to a limited extent) that this was equivalent to a second procedure in which the zero-order wave-functions were assumed to be independent of the ionization and successive orders of perturbations were included. Recently it has been shown that a linear theory, which is a combination of the Slater theory and an empirically derived correction, predicts the separations of terms in any one configuration with about the same accuracy as the Bacher and Goudsmit theory; in this theory, the wave-functions are allowed to depend on the degree of ionization. It is shown that the Bacher and Goudsmit theory can be interpreted in a third way that is consistent with this linear theory. In the light of this latter interpretation, Racah has suggested an empirical modification of the Bacher and Goudsmit theory that often leads to better results; this suggestion has been incorporated in the present paper. A.

535.338 : 535.417

10934. Natural line widths of spectral lines and spectral band widths from monochromators determined by means of phase contrast interferences. E. Ingelstam. *Optica Acta*, **1**, 73–80 (*Sept.*, 1954).

An examination is made of how the phase contrast method, which is not necessarily limited to phase differences in the object which are small compared with the wavelength, works with phase differences of very many wavelengths. When used in this way, a set-up such as a phase contrast refractometer [Abstr. 3972 (1953)] offers a simple method for the measurement of natural line widths of spectral lines. Formulae for different line shapes are given. Experimental material is presented for a mercury lamp with different monochromator widths, utilizing the 5461 line. The use of the Hg^{198} lamp in this new type of interferometry is discussed. A.

535.338

10935. Structure of the spectrum of Nb II in the extreme ultraviolet. L. Iglesias. *An. Real. Soc. Espan. Fis Quím.*, **50(A)**, 135–44 (*July–Aug.*, 1954) *In Spanish.*

New measurements in the region 1579 to 2211 Å of the vacuum spark spectrum of niobium have been made. Twenty new odd atomic energy levels have been found. The following spectral terms have been identified among them: a S^0 quintet, two G^0 triplets and three F^0, G^0, H^0 singlets. 330 new lines are tabulated, of which 156 are classified with the Humphreys and Meggers levels and 184 with the levels now identified. The greater part of these new levels belong to the electronic configuration $4d^2 5s5p$. A.

535.338.1

10936. A spectrophotometric atlas of the $^2\Sigma^+ - {}^2\Pi$ transition of OH. A. M. Bass and H. P. Broida. *Circ. Nat. Bur. Stand., No.* 541, 22 *pp.* (1953).

535.338.332

10937. The optical spectrum of plutonium and its hyperfine structure. M. van den Berg and P. F. A. Klinkenberg. *Physica*, **20**, 461–80 (*Aug.*, 1954).

Plutonium is excited in a hollow cathode discharge and the emitted light in the wavelength region 2900–6490 Å is observed by means of prism spectrographs. The wavelengths of nearly 2000 Pu-lines are measured against argon reference lines with an accuracy corresponding to an approximately constant mean wave number error of ±0·2 K in the region above 3705 Å and of ±1·0 K in the shorter wavelength region. By comparing the intensities with those observed in spark discharges by other authors, a preliminary separation of the stronger Pu I- and Pu II-lines is possible. About 85% of the lines observed in the hollow cathode belong to Pu I. This is confirmed by a recent paper on the furnace spectrum. A list is given of the 714 strongest observed lines, with the assignment to Pu I or Pu II. The 75 strongest Pu-lines between 4020 and 6200 Å are examined by means of etalons, and a hyperfine structure doubling is found in 30 of them, with separations of 34 to 181 mK. It is proved that this doubling is due to a Pu^{239} nuclear spin value $I = \frac{1}{2}$. Intensity measurements in some selected doublets show that high J-values are involved in the observed transitions. Possible consequences with regard to the electronic structure of the free atom are discussed. The nuclear spin value of Pu^{239} is considered in the light of the nuclear shell model. A.

535.338.332

10938. Precision wavelength and isotopic shift measurements of germanium arc lines. G. V. Deverall, K. W. Meissner and G. J. Zissis. *Phys. Rev.*, **95**, 1463–8 (*Sept.* 15, 1954).

The employment of an atomic-beam light source and of interferometric equipment made it possible to obtain information about the line structure and precision wavelength of eight Ge I lines arising from transitions between the lowest even and odd energy levels of germanium. Despite the high resolving power employed, it was impossible to observe line splittings. By comparing the total width of the lines with that expected from the beam data one can estimate that the isotope shift between consecutive even Ge isotopes is smaller than 0·005 cm^{-1}. The wavelength of the centre of gravity of the different lines, however, could be determined within ±0·00004 Å. This limit of error is in agreement with the wave number deviations obtained by the application of the Ritz combination principle. A.

535.338.332

10939. Isotope shift in neutral carbon. J. P. Nicklas. *Phys. Rev.*, **95**, 1469–71 (*Sept.* 15, 1954).

There is a possibility that the discrepancy between the experimental values of spectral isotope shift in light elements and the values calculated by including nuclear motion may be reduced by using improved one-electron wave-functions. In order to investigate this possibility and at the same time to make a comparison with recently obtained experimental data, the shift of the transition $2p^2\,{}^1S - 2p3s\,{}^1P(\lambda = 2478 \cdot 5\,\text{Å})$ of neutral carbon has been calculated using Hartree one-electron functions without exchange. The functions for the $2p3s$ configuration were calculated by the author for this purpose. The agreement with the experimental value is comparable to that obtained for other elements with this type of function. A comparison of the term shifts is made for both the ^3P and ^1S terms of the $2p^2$ configuration using Hartree functions with and without exchange and analytic functions of the Morse, Young, and Haurwitz type. The use of functions with exchange produced a significant change in the calculated term shifts which indicates that it may be possible to improve the agreement between calculated and observed transition shifts. A.

535.338.332

10940. Isotope shift in neutral oxygen. C. E. Treanor. *Phys. Rev.*, **95**, 1472–3 (*Sept.* 15, 1954).

Isotope shifts in levels of the first and second excited configurations of oxygen were calculated using Hartree one-electron wave-functions, computed for $1s^2 2s^2 2p^3 3s$ and $1s^2 2s^2 2p^3 3p$. The suitability of the wave-functions for this type of calculation can be checked with recent experiments in nine spectral lines of neutral oxygen. The discrepancies between calculated and observed shifts are from $-0 \cdot 09\ cm^{-1}$ to $+0 \cdot 09\ cm^{-1}$ for the shift between O^{18} and O^{16}. It appears that better one-electron wave-functions (e.g. Hartree–Fock functions including exchange) could account for these discrepancies. A.

535.338.332 : 539.153

10941. Multiplet separation factors in the spectrum of chromium II. V. Suryanarayana and V. Ramakrishna Rao. *Indian J. Phys.*, **28**, 285–96 (*June*, 1954).

Formulae for the multiplet separation factors in the configurations $3d^4 \cdot 4s$ and $3d^4 \cdot 4p$ are derived and used for the calculation of the multiplet separations. The values are compared with the experimental data. A.

535.338.4

10942. Band spectra of nitric oxide in the visible and near infra-red regions. M. Ogawa. *Sci. of Light [Tokyo]* **2**, 87–94 (*March*, 1953).

Emission bands in the visible and the near i.r. regions were photographed, using electrical excitation of flowing NO gas. Vibrational analysis was made of two band systems among others. These band systems are shown to be due to the transition of $b \rightarrow B\,{}^2\Pi$ (B being the upper state of the β-system) and $b' \rightarrow B\,{}^2\Pi$ (b' being a new level) of the NO molecule. The results formerly obtained by Tanaka and Ogawa on the band spectra of NO in the visible region was corrected. A.

535.338.4

10943. On the O_2 atmospheric bands appearing in the emission spectrum. M. Shimazu. *Sci. of Light [Tokyo]* **2**, 95–103 (*March*, 1953).

Forbidden atmospheric oxygen bands were observed in the emission spectrum of pure oxygen, and of oxygen containing H_2O and N_2, both in the direct discharge and in the afterglow. Experimental conditions are described, and three spectrograms and a microphotometer curve are reproduced. Plausible mechanisms of the radiation processes are suggested. A.

535.338.4 : 539.132

10944. Computation of intensities of vibrational spectra of electronic bands in diatomic molecules. II. C. Manneback and A. Rahman. *Physica*, **20**, 497–500 (*Aug.*, 1954).

Following up the technique of Pt I [Abstr. 2017 (1952)] which provides very simple recurrence relations for the calculation of transition-moments, similar recurrence relations are now developed showing that if electrical anharmonicity is introduced while conserving the mechanical harmonicity of the two electronic potentials the calculation of the matrix elements can be made with equal ease. A.

535.338.4 : 539.132

10945. On the working of some theories of vibrational transition probabilities. N. R. Tawde and B. B. Laud. *Proc. Nat. Inst. Sci. India*, **20**, 259–64 (*May–June*, 1954).

Attempt has been made to test the relative merits of two theoretical methods of calculating transition probabilities, viz. (i) Hutchisson's method and (ii) Gaydon and Pearse's method of numerical integration. Transition probabilities of C_2 (Swan) bands have been calculated by these methods and these have been studied in comparison with the carefully determined experimental data. It has been observed that in spite of the approximate nature of Hutchisson's theory, the weight of agreement is more in favour of it than the method of numerical integration. The disagreement with the latter method is attributable to the various approximations involved in the distortion process, departure from normalization, etc. The new method suggested by Pillow takes these factors into account and values calculated by this method agree with the experimental values of the present authors as well as some earlier observations on flames, thus justifying the improvements previously visualized by the authors. A.

535.338.4 : 551.594.5

10946. The intensity distribution in the second positive band system of nitrogen in a laboratory light source and in the aurorae. A. Omholt. Note in *J. atmos. terrest. Phys.*, **5**, 63–6 (*March*, 1954).

The intensity distribution in the second positive band system of N_2 emitted from an ordinary discharge lamp is measured, and the relative transition probabilities are derived. Vegard's intensity measurements of these bands in high latitude aurorae are discussed, the most likely relative population of the upper vibrational levels ($N_2C^3\Pi_u$) being found to be $g(0) = 1{\cdot}0$, $g(1) = 0{\cdot}6$ and $g(2) = 0{\cdot}35$. It can be shown that the excitation mechanisms $N_2(^1\Sigma_g^+) + e \rightarrow N_2(C^3\Pi_u) + e$ or $N_2^+(X^2\Sigma_g^+) + e \rightarrow N_2(C^3\Pi_u) + h\nu$ cannot alone be responsible for this population. A.

535.343 : 539.132

The electronic spectra of aromatic molecules. *See Abstr.* 11307

535.343–14 : 539.133

10947. Microwave spectrum and structure of benzonitrile. R. D. Lide, Jr. *J. chem. Phys.*, **22**, 1577–8 (*Sept.*, 1954).

The rotational spectrum of benzonitrile has been studied in the one-centimetre region, and approximately twenty absorption lines have been fitted to the rigid asymmetric-rotor theory. The principal moments of inertia are 89·370, 326·740 and 416·183 AUA². The evidence indicates a planar symmetric structure with ring dimensions essentially the same as in benzene. The dipole moment is 4·14 ± 0·05 Debye units. A.

535.343.2

10948. Study of a third hydrogenlike series of absorption lines of Cu_2O. S. Nikitine, G. Perny and M. Sieskind. *C.R. Acad. Sci.* [*Paris*] **239**, 247–9 (*July* 19, 1954) *In French.*

See Abstr. 4358 (1954). A new series was observed in the orange-red region. The spectra were taken at the temperature of boiling nitrogen. The appropriate photometric curve is reproduced. A. J. TAYLOR

535.343.2–15

10949. Infrared absorption spectra of metallic salts containing the group XO_4 in the region of its deformation vibrations. C. Duval and J. Lecomte. *C.R. Acad. Sci.* [*Paris*] **239**, 249–51 (*July* 19, 1954) *In French.*

Spectra of powdered metallic salts containing XO_4, X being Si, P, S, Cl, V, Cr, Mn, As, Se, Mo, I, W or Re, were taken in the region 290–650 cm^{-1}, where the deformation frequencies of these groups are to be found. The symmetry of these groups determines the frequencies which can be observed, so the compounds could be classified as containing tetrahedral XO_4 groups or perturbed groups. It was found that water of crystallization had a great influence on the spectra. A. J. TAYLOR

535.343.2–15 : 548.7

10950. Optical investigations of impurity levels in silicon. E. Burstein, E. E. Bell, J. W. Davisson and M. Lax. *J. phys. Chem.*, **57**, 849–52 (*Nov.*, 1953).

Infrared measurements over the range of 2 to 38 μ have been carried out for a number of *p*-type silicon specimens, including boron-doped single-crystal specimens. At liquid helium temperature these specimens exhibit optical absorption by neutral impurities involving (*a*) photoionization of bound charge carriers, which is accompanied by photoconductivity, and (*b*) optical excitation of bound charge carriers from the ground state to higher energy states, which appears as relatively narrow bands at wavelengths beyond the photoionization limit. Three excitation bands are observed in the boron doped specimens at 28·7, 31·2 and 36·0 μ, which are attributed to 1*s*–4*p*, 1*s*–3*p* and 1*s*–2*p* transitions, respectively. The energy levels of the boron centres calculated from these bands correspond closely to those of a hydrogen model having an ionization energy of 0·046 eV and indicate an effective mass for holes $m_h = 0{\cdot}45\ m$ and a radius for the ground state orbit of 13·5 Å. The boron ionization energy is independent of concentrations up to densities of 6×10^{17} impurity centres/cm³. A second type of impurity centre having an ionization energy of 0·07 eV is also observed in a polycrystalline specimen. For this centre the excitation bands do not conform to those of a simple hydrogen model. A.

535.343.32 : 535.372

10951. The influence of the solvent on the spectra of absorption and of fluorescence of substituted nitrostilbenes. E. Lippert. *J. Phys. Radium*, **15**, 627–9 (*July–Aug.–Sept.*, 1954) *In French.*

The positions of the absorption and fluorescence bands have been measured for a large number of solvents. While the fluorescence changes are large, those of absorption band are much smaller: for example, *p*-nitro-*p*′-dimethylamino stilbene fluoresces blue in cyclohexane and infrared in pyridine, but the absorption band moves only from violet to blue. The reasons for these changes are discussed, and mention is made of the effects of mixing solvents and of temp. changes. S. T. HENDERSON

535.343.4

10952. The fundamental vibration-rotation bands of $^{13}C^{16}O$ and $^{12}C^{18}O$. I. M. Mills and H. W. Thompson. *Trans Faraday Soc.*, **49**, 224–7 (*March*, 1953).

Rotation lines in the fundamental vibration bands of $C^{13}O^{16}$ and $C^{12}O^{18}$ have been measured, using very high resolving power and more accurate wavelength calibrations than previously. The molecular rotational and vibrational constants have been deduced and compared in relation to the mass differences between these molecules and the main species $C^{12}O^{16}$. A.

535.343.4

10953. The absorption spectrum of BiBr. P. K. Sur and K. Majumdar. *Proc. Nat. Inst. Sci. India*, **20**, 235–40 (*May–June*, 1954).

Morgan observed two systems of bands in absorption for BiBr molecule in the visible regions with origins at 4045·7 Å and 4869·1 Å. The lower frequency system degrades to the red, but the direction in which the other system degrades is in doubt. In the present paper are reported three new systems observed in absorption in the ultraviolet regions λλ 2968–2709, λλ 2450–2336 and λλ 2350–2200 respectively. The bands are degraded to the violet in each case, and the band heads fit in the following formula:

$$\text{system } C,\ \nu = 34362{\cdot}9 + 503{\cdot}8u' - 0{\cdot}40u'^2 - 209{\cdot}3u'' + 0{\cdot}40u''^2;$$

$$\text{system } D,\ \nu = 41633{\cdot}3 + 652{\cdot}5u' - 0{\cdot}25u'^2 - 209{\cdot}2u'' + 0{\cdot}60u''^2;$$

$$\text{system } E,\ \nu = 43502{\cdot}33 + 319u' - 5{\cdot}5u'^2 - 209{\cdot}2u'' + 0{\cdot}60u''^2,$$

where $u = v + \frac{1}{2}$. Band heads due to the isotopic molecule $BiBr^{81}$ were not recorded. A.

535.343.4–14 : 535.338.334

10954. Temperature dependence of microwave absorption coefficient. P. Swarup. *J. sci. industr. Res.*, **13B**, 389–92 (*June*, 1954).

The microwave absorption coefficient values at 3 cm wavelength have been measured for ammonia and ethyl chloride at temperatures varying from − 8° to 50°C and at pressures varying from 15 to 75 cm of Hg. In the case of ammonia, the absorption coefficient at low pressures varies at $T^{-5/2}$ which indicates that the pressure broadening parameter $\Delta\bar{\nu}$ varies at $T^{-1/2}$. In the case of ethyl chloride variation of absorption coefficient with T at low pressure follows a T^{-3} law indicating that $\Delta\bar{\nu}$ varies at T^{-1}. As the pressure increases at 1 atm, the temperature dependence of absorption coefficient in both cases tends to follow T^{-1} law. This change with pressure is due to the increasing interaction between absorbing molecules at higher pressures. A.

535.343.4–14 : 539.133

10955. Molecular microwave spectra tables. P. Kisliuk and C. H. Townes. *Circ. Nat. Bur. Stand.*, *No.* 518, 127 *pp.* (1952).

This group of tables gives the frequencies, assignment of quantum numbers, and intensities of about 1800 microwave absorption lines. The best available values of other pertinent molecular data, such as rotational constants, dipole moments, quadrupole coupling constants, and rotation-vibration interaction constants are also included. The frequencies are listed once for each molecule, and again in consecutive ascending order of frequency. References are given for all data included. For easy calculation of quadrupole hyperfine structure, Casimir's function is tabulated up to $J = 10$, and $I = 9/2$. Explanations of the tables and a short discussion of microwave spectra and important formulae are given in the introduction. A.

535.343.4–15

10956. Measurements of intensities and line widths in infrared spectra of gases or vapours. J. Vincent-Geisse. *C.R. Acad. Sci.* [*Paris*] **239**, 251–3 (*July* 19, 1954) *In French.*

Such measurements were taken for CO, NO, CH_4 and NO_2. The intensities of the fundamentals were calculated from these. There is good agreement with results obtained by other authors. A. J. TAYLOR

535.343.4–15

10957. Vibrational spectra of trifluoroethylene and trifluoroethylene-d_1. D. E. Mann, N. Acquista and E. K. Plyler. *J. chem. Phys.*, **22**, 1586–92 (*Sept.*, 1954).

The infrared spectra of gaseous $F_2C : CFH$ and $F_2C : CFD$ have been investigated in the range 2–50 μ. Complete and satisfactory vibrational assignments have been achieved. The a' fundamentals of the H compound are 3150, 1788, 1362, 1264, 1171, 929, 623, 485, 232; and the a'' modes occur at 750, 555 and 305 cm^{-1}. The corresponding fundamentals for the heavy molecule are 2347, 1767, 1323, 1200, 983, 855, 620, 480 and 228 in a', and 612, 528 and 291 cm^{-1} in species a''. Tables of the thermodynamic functions for the ideal gases are given. A.

535.343.4–15 : 535.375.56

10958. Vibrational spectrum of hexafluoro-2-butyne. F. A. Miller and R. P. Bauman. *J. chem. Phys.*, **22**, 1544–8 (*Sept.*, 1954).

Infrared and Raman spectra have been obtained for hexafluoro-2-butyne, including qualitative depolarizations and gaseous state frequencies for the stronger Raman lines. The data provide good evidence that D_{3d} selection rules are followed. From this it appears that there must be hindered rotation between the CF_3 groups, with the "staggered" configuration being stable. An assignment of fundamental frequencies has been made for this model. The origin of the potential barrier is not known. A.

535.343.4–15 : 539.132

Vibration-rotation bands and rotational constants of cyanogen and diacetylene. *See Abstr.* 11277

535.343.4–31

10959. Investigations of atomic and molecular absorption spectra. III. Ultra-violet absorption spectra of indium vapour. W. R. S. GARTON. *Proc. Phys. Soc.* [*London*] *A*, **67**, 864–8 (*Oct.*, 1954).

For Pt II, see Abstr. 5020 (1952). By use of a King furnace the absorption spectra of In vapour in the near and vacuum ultraviolet have been observed. Fourteen new absorption lines of the In I^{b} spectrum have been found in the Schumann region, and the normal sharp and diffuse series extended. Classification of the strongest of the vacuum ultraviolet lines leads to an amendment of the sp^2 term assignments of McCormick and Sawyer in the isoelectronic spectrum of Sn II. A.

535.343.4–32

10960. On the absorption spectrum in the $1s\sigma 3p\pi\,{}^1\Pi_{cd} \leftarrow (1s\sigma)^{2}\,{}^1\Sigma_g^+$ system of the hydrogen molecule. T. NAMIOKA. *Sci. of Light* [*Tokyo*] **2**, 73–86 (*March*, 1953).

The absorption spectrum of the hydrogen molecule in the extreme ultraviolet region 900 to 700 Å was photographed by the use of a 3 meter grazing incidence vacuum spectrograph. Helium continuum was employed as light source for the continuous background. In treating the *D–A* band system that has not yet been completely analysed up to now, the author has been successful in analysing nine bands from (0–0) to (8–0) and in deriving various molecular constants of each state. The molecular constants for the $1s\sigma 3p\pi\,{}^1\Pi_{cd}$ are expressed by:

$$\begin{aligned}
(B_v^x)_c &= 30{\cdot}519 - 1{\cdot}5156(v+\tfrac{1}{2}) \\
&\quad - 0{\cdot}0057699(v+\tfrac{1}{2})^2 + 0{\cdot}0015170(v+\tfrac{1}{2})^3, \\
(B_v^x)_d &= 31{\cdot}942 - 1{\cdot}6353(v+\tfrac{1}{2}) \\
&\quad - 0{\cdot}03009(v+\tfrac{1}{2})^2 - 0{\cdot}00096597(v+\tfrac{1}{2})^3, \\
(D_v^x)_c &= -\,0{\cdot}02371 - 0{\cdot}00207(v+\tfrac{1}{2}) \\
&\quad + 0{\cdot}0001131(v+\tfrac{1}{2})^2, \\
(D_v^x)_d &= -\,0{\cdot}02604 + 0{\cdot}0009863(v+\tfrac{1}{2}) \\
&\quad - 0{\cdot}00001673(v+\tfrac{1}{2})^2.
\end{aligned}$$

These values are slightly different from those of Jeppesen and Tanaka who used the data of vibrational states. A.

535.361

10961. On the subject of artificial lighting under water. A. IVANOFF. *Rev. Opt.*, **33**, 369–76 (*Aug.*, 1954) *In French.*

Experience proved artificial lighting in sea-water to be extremely difficult. The necessary power increases very quickly with the extent to be reached. As brightness of the diffused veil increases at the same time, a maximum extent is quickly reached. Estimates of these values are given. A.

535.37

10962. Luminescence to-day. J. EWLES. *Sci. Progr.*, **42**, 449–55 (*July*, 1954).

A survey of the problems and the present state of knowledge of the mechanism of luminescence.

535.371

10963. Emission and absorption in luminescent centers at low temperatures. C. C. KLICK. *J. phys. Chem.*, **57**, 776–9 (*Nov.*, 1954).

Measurements on emission and absorption of luminescent centres at low temperatures show these results: the emission and absorption bands remain broad at the lowest temperatures; emission and absorption band-widths vary as the square root of the temperature at high temperatures, but vary at a lesser rate and approach a constant value at low temperatures; and some systems show an emission composed of equally spaced "lines." These data are compared with a model which treats the luminescent centre as a one-dimensional harmonic oscillator. A.

535.371

10964. Theory of the luminescence of impurity-activated ionic crystals. F. E. WILLIAMS. *J. phys. Chem.*, **57**, 780–4 (*Nov.*, 1953).

The absolute theory of the absorption and emission of impurity-activated ionic crystals is reviewed. The detailed atomic rearrangements following the optical transitions and the equilibrium distributions among accessible atomic configurations of the activator system are determined quantitatively. The spectra can be determined either from the Franck–Condon principle or by direct evaluation of the matrix elements for the transitions from the vibrational levels of the initial state to the vibrational levels of the final state. Important refinements in the theory of activator systems are reported and are shown to improve the agreement of the theory with experiment. The angular dependence of the wave-functions of excited states of thallous and manganous activator ions is shown to affect the properties of their activator systems in alkali halide phosphors. The first-order perturbation of the energies of activator ions by the crystal field is evaluated and found to be appreciably different for the ground and excited states of the thallous ion in alkali halides. A.

535.371

10965. The quenching of the fluorescence of anthracene gas. W. S. METCALF. *J. Chem. Soc.*, **1954**, 2485–6 (*July*).

The rates of reaction of various substances with excited anthracene molecules increase with falling temperature as would be expected if quenching collisions were increased in number by van der Waals attractive forces. A.

535.371 : 548.7

10966. Low-temperature luminescence of cadmium sulfide. L. R. FURLONG. Letter in *Phys. Rev.*, **95**, 1086 (*Aug.* 15, 1954).

A CdS crystal excited by 3650 Å radiation at 4°K shows no photoconductivity but an edge emission with six peaks between 5100 and 5400 Å. Results indicate ground state vibrational levels with 296 cm^{-1} and excited state with 199 cm^{-1} separations. Ground state levels may correspond to a reported absorption at 34 μ. G. F. J. GARLICK

535.372

10967. Fluorescence spectra of cuprous halides at low temperatures. I. TSUJIKAWA AND E. KANDA. *Sci. Rep. Res. Insts Tōhoku Univ. A*, **6**, 220–3 (*June*, 1954).

The spectrophotographs of the visible fluorescence spectra of cuprous halides excited by cathode ray were taken at temperatures ranging from room to liquid oxygen temperature. In cuprous chloride a colour change of fluorescence was observed, that is, green fluorescence observable at high temperatures which disappeared at about —85°C, and below this temperature red fluorescence. The red band also existed at high temperatures with considerable intensity but was covered with a green band. In bromide and iodide, no considerable change was observed and only the red fluorescence appeared over a certain range of temperature. A.

535.372

10968. Fluorescence spectra of organic crystals. J. B. BIRKS AND G. T. WRIGHT. *Proc. Phys. Soc.* [*London*] *B*, **67**, 657–63 (*Sept.*, 1954).

Relative quantum intensity measurements have been made of the fluorescence spectra, excited by 254 mμ radiation, of crystalline anthracene, *trans*-stilbene, *para*-terphenyl and diphenylacetylene at room temperature, using a calibrated spectrophotometer and photomultiplier. Observations were made of the reflection and transmission spectra from 1 cm thick crystals of each compound, and also of the reflection spectrum from a thin microcrystalline layer of anthracene. The latter corresponds closely to the true molecular emission. Due to self-absorption, this has only a probability $k_e = 0{\cdot}24$ of direct transmission through a thick crystal. This value confirms the difference in technical and molecular photofluorescence decay times, reported by Birks and Little [Abstr. 321 (1954)]. For the other materials, k_e is larger, and for *para*-terphenyl it is practically unity. Vibrational bands have been resolved, which have been assigned to the 1–0 and 0–n (n = 0 to 3) transitions in anthracene, and to the 0–n (n = 0 to 5) transitions in *para*-terphenyl. The 1–0 transition in anthracene is attributed to fluorescence prior to the establishment of thermal equilibrium. A.

535.375.5

10969. Density effects in the Raman spectrum of ammonia. C. A. PLINT, R. M. B. SMALL AND H. L. WELSH. *Canad. J. Phys.*, **32**, 653–61 (*Oct.*, 1954).

The Raman spectra of ammonia as a high pressure gas, liquid, solid, and aqueous solution are compared with the spectrum of the low pressure gas. At gas pressures up to 80 atm. no appreciable hindering of rotation is present; a weak satellite of the ν_1 band is an unexplained feature of the spectrum at high pressure. The spectra of the liquid, solid, and aqueous solution are interpreted without postulating dimerization; the three higher frequency maxima can be assigned to the $2\nu_4$, ν_1, and ν_3 vibrations if it is assumed that hindering of rotation is almost complete. The rotational fine structure found by early workers for the aqueous solution could not be observed even at high dispersion. A.

535.375.55

10970. On the Raman spectra of ethylene dichloride in solutions of different strengths. S. B. BANERJEE. *Indian J. Phys.*, **28**, 205–8 (*May*, 1954).

The Raman spectra of solutions of ethylene dichloride of concentrations 25% and 50% by volume in heptane and cyclohexane have been studied and the relative intensities of the lines 754 cm^{-1} and 654 cm^{-1} have been measured in each case and compared with the values observed in the case of pure liquid. It has been observed that the ratio I_{754}/I_{654} increases when the liquid is dissolved in either of the two solvents to make 50% solutions and the ratio increases further when the concentration is diminished. It is pointed out that these results support the conclusion arrived at by Bishui (1948) that one of these two lines is due to associated molecules, and are contradictory to the conclusions drawn by Kuratani (1952) that association of molecules has nothing to do with the origin of these lines. A.

535.375.56

10971. On the Raman spectra of acetyl chloride and chloroacetyl chloride in the vapour state. M. MAZUMDER. *Indian J. Phys.*, **28**, 297–301 (*June*, 1954).

The Raman spectra of acetyl chloride and chloroacetyl chloride in the vapour state at 100°C and 150°C respectively have been studied and compared with those of the substances in the liquid state at room temperatures nearly equal to those of the vapour. It is observed that the relative intensities of some of the prominent lines undergo changes in both the cases when the change from liquid to vapour state takes place. The intensity of the line 590 cm^{-1} in the case of acetyl chloride and 560 cm^{-1} in the case of chloroacetyl chloride increases appreciably with vaporization. The frequency-shifts of some of the prominent lines in both the cases increase with vaporization of the liquids. It is pointed out that the influence of strong intermolecular field between the neighbouring molecules in the liquid state owing to the presence of chlorine atom in the molecule is responsible for all these changes. A.

535.375.56

10972. High resolution Raman spectroscopy of gases. III. Raman spectrum of nitrogen. B. P. STOICHEFF. *Canad. J. Phys.*, **32**, 630–4 (*Oct.*, 1954).

For Pt II, see Abstr. 8198 (1954). The pure rotational spectrum and the Q branch of the 1–0 band of N_2 were photographed in the second order of a 21 ft grating. An analysis of the rotational spectrum yields the rotational constants $B_0 = 1{\cdot}9897_3 \pm 0{\cdot}0003$ cm^{-1} and $D_0 = (6{\cdot}1 \pm 0{\cdot}5)\times 10^{-6}$ cm^{-1}. The value of B_0 together with the B_v values obtained from the electronic bands of N_2 gives $B_e = 1{\cdot}9987_4 \pm 0{\cdot}0003_5$ cm^{-1}. Hence $r_e = 1{\cdot}0975_8 \pm 0{\cdot}0001$ Å. Revised values of the vibrational constants have also been calculated using the results of the present work and the published data on the electronic spectra. A.

535.375.56

10973. High resolution Raman spectroscopy of gases. IV. Rotational Raman spectrum of cyanogen. C. K. MØLLER AND B. P. STOICHEFF. *Canad. J. Phys.*, **32**, 635–8 (*Oct.*, 1954).

The rotational Raman spectrum of cyanogen gas at ½ atm. pressure has been photographed in the second order of a 21 ft. concave grating spectrograph. The simplicity of the spectrum and the observed intensity alternation of the lines show that C_2N_2 is a linear symmetric molecule. An analysis of the spectrum yields for the rotational constants $B_0 = 0{\cdot}15752 \pm 0{\cdot}00015\ \mathrm{cm}^{-1}$ and $D_0 = 4\times10^{-8}\ \mathrm{cm}^{-1}$. By assuming a value for the $C \equiv N$ bond length of 1·157 Å, the length of the C–C single bond was calculated to be 1·380 Å. A.

535.376/.377

10974. Fluorescence and thermoluminescence of ice. L. I. Grossweiner and M. S. Matheson. *J. chem. Phys.*, **22**, 1514–26 (*Sept.*, 1954).

Experiments on the X-ray excited fluorescence and thermoluminescence of pure ice and ice containing certain additives are described. The luminescent spectra are explained by a model in which the primary process is the radiative capture of electrons by impurity cations. The first-order build-up of fluorescence and temperature dependence of luminous intensity are interpreted by the breakdown and formation of the dipole sheath surrounding the dissolved ions. From this viewpoint, the activation energy for rotation of a sheath ice dipole from the normal lattice position to the aligned configuration is calculated to be 0·07 eV. The principal trap depth determined from the glow curve is 0·32 eV, a correction for the luminous efficiency being incorporated in the calculation; the corresponding s value is $2\times10^8\ \mathrm{sec}^{-1}$. Possible mechanisms for the first-order thermoluminescence are given. A.

535.376

10975. Fluorescence caused by high-energy radiations. M. Ageno. *R.C. Ist. Super. Sanità*, **17**, *Pt VI*, 439–55 (1954) *In Italian.*

The main characteristics of the phenomenon of scintillations in organic crystals and solutions are investigated, and a first attempt is made to provide a coherent picture of the phenomenon in the two cases mentioned, emphasizing the gaps in experimental knowledge that remain. A.

535.376

10976. Response of anthracene scintillation crystals to monoenergetic soft X-rays. W. H. Robinson and W. Jentschke. *Phys. Rev.*, **95**, 1412–14 (*Sept.* 15, 1954).

The response in the range from 9 keV to 24 keV in a scintillation detector has been investigated. The results show that the response to short-range electrons produced within the crystal by X-rays is about the same as the response to electrons with equal energy incident on the surface of the crystal. In agreement with previous results, the specific fluorescence (dL/dx) is smaller for slow electrons than for heavy particles of the same specific energy loss (dE/dx). A.

535.376

10977. Radiations from water under alpha-particle bombardment. E. W. T. Richards. *Proc. Phys. Soc.* [*London*] *A*, **67**, 922–6 (*Oct.*, 1954).

Experiments are described in which quanta emitted by water under α-particle bombardment have been detected. Differentiation between light pulses arising from liquid water and any gas present above the water surface has been accomplished by utilizing the difference in their times of duration. From measurements made of the absorption of the quanta from water by various gases an upper limit of the wavelength of 1900 Å is suggested. The importance of quantum emission in radiation chemical experiments is discussed but, owing to the apparently very high absorption coefficient of the water, it is difficult to assess the contribution from this phenomenon. A.

535.39 : 539.215.9

10978. Reflectance measurements on siliceous dusts and powders. E. V. Smith. Letter in *Brit. J. appl. Phys.*, **5**, 340–1 (*Sept.*, 1954).

Graphs of optical reflecting power for eight different forms of siliceous powder are shown, the wavelength range being 2000–10 000 Å. The effect upon the reflecting power of particle size and storage after grinding is discussed. The variation of reflectivity caused by etching away the surfaces of the particles with HF suggests that the particles have surface layers about 0·12 μ thick which have different optical properties from their homogeneous cores, diameter 1 μ. D. G. AVERY

535.412

10979. Multiple reflection interference with variable reflection factor. J.-J. Hunzinger. *Rev. Opt.*, **33**, 455–60 (*Sept.*, 1954) *In French.*

Generally the contrast of multiple-wave fringes obtained by reflection, and their position in the field, are intricate functions of several parameters. The two special cases of null and unitary contrast are described. The position of fringes is shown to be fixed relative to the reflecting power of the second mirror when fringes have the best contrast. These properties can be used to establish the phase of the first wave relative to those following. A.

535.417

10980. The second-order aberrations in the interferometric measurement of concentration gradients. II. Experimental verification of theory. R. Forsberg and H. Svensson. *Optica Acta*, **1**, 90–3 (*Sept.*, 1954).

For Pt I, see Abstr. 1209 (1954). The Wiener skewness of an interferometrically recorded refractive index gradient curve has been measured for the first time as a function of the longitudinal position of the cell in relation to the location of the conjugate image plane of the photographic plate. A complete agreement was found between these measurements and a recently published theoretical treatment of this skewness and other aberrations in interferometric recording of refractivity. A.

535.43 : 536.581.2

10981. A thermostatic chamber for the measurement of light scattering from solids at elevated temperatures. J. J. Keane and R. S. Stein. *Rev. sci. Instrum.*, **25**, 892–4 (*Sept.*, 1954).

A chamber is described which, in conjunction with a Zimm type light scattering apparatus, may be used to determine the angular dependency of the scattering from polymer films at temperatures between 30°c and 200°c at scattering angles between 10° and 70° from the incident beam. The temperature is maintained by circulating heated air. The use of this chamber is illustrated with a series of measurements of scattering from a Polythene film. A.

535.43.07 : 578.087.8

10982. A nephelometer of wide range for bacteriological use. E. O. Powell. *J. sci. Instrum.*, **31**, 360–2 (*Oct.*, 1954).

Describes an instrument in which the light transmitted by a suspension is compared with that scattered. The densest bacterial suspensions normally encountered can be measured without dilution. A.

535.434

10983. Theory of light scattering and refractive index of solutions of large colloidal particles. B. H. Zimm and W. B. Dandliker. *J. phys. Chem.*, **58**, 644–8 (*Aug.*, 1954).

A general equation for the intensity of light scattered by a suspension of independently scattering particles is derived $V_{0,\mathrm{v}} = (Mcn^2/\lambda_0^4 N_0)[4\pi^2(dn/dc)^2 + (\lambda_0^2/4)(\tau/c)^2]$. $V_{0,\mathrm{v}}$ is the Rayleigh ratio of the vertically polarized component of the excess scattered light at $\theta = 0$ with the electric vector vertical in the incident light. The other quantities involved are the molecular weight, M, concentration c, refractive index n of the solution, the wavelength λ_0 *in vacuo*, Avogadro's number N_0, the refractive index increment (dn/dc) and the excess turbidity, τ, due to the solute. The second term of the equation, which is important in the case of very large particles, has usually been omitted in the past. For spheres, a general relationship between dn/dc, particle size α and refractive index of particle and medium can be deduced: $dn/dc = 3nR(i_1^*)/2\alpha^3 D$ where $R(i_1^*)$ is obtained from tabulations of the Mie theory. The density of the particle is D and $\alpha = 2\pi r/\lambda$ where r is sphere radius and λ is the wavelength in the medium. For small spheres the refractive index equation reduces to the well-known result: $dn/dc = (3n/2D)(m^2 - 1)(m^2 + 2)$, where m is the relative refractive index. A.

535.435

10984. On light scattered by liquid crystals of the nematic type. P. Chatelain. *Bull. Soc. Franç. Minéral Crist.*, **77**, 353–61 (*Jan.–March*, 1954) *In French.*

The experimental results are interpreted in terms of packets of molecules of radius about 10^{-5} cm, whose orientation fluctuates about the axis of isotropy.

L. G. CARPENTER

535.51 : 548.0

10985. Correlation of polarized light phenomena with the orientation of some metal crystals. C. J. Newton and H. C. Vacher. *J. Res. Nat. Bur. Stand.*, **53**, 1–12 (*July*, 1954).

A photometric study was made of the reflection of plane-polarized light normally incident in a metallographic microscope upon specimens of tin, aluminium and monel, with various surface treatments. A high degree of correlation was found in most cases between the extinction position and the projection of the optic axis or of the cubic axis making the greatest angle with the surface normal. Moreover, a fourth-power sine relationship was observed between the change of intensity and the angle between the surface normal and the optic axis in tin. The intensity correlation in the case of the cubic metals was not so clear, but a slight indication of position dependence was observed for aluminium. The results indicate that the optically anisotropic effects observed with cubic metals can be caused both by anisotropic films and by oriented surface contours, but that the latter is the source of those effects that are correlated with the crystallographic orientation of the grain. A.

535.514.2 : 532

10986. Study of the structure of a liquid surface by light reflection. V. A. Kizel'. *Zh. éksper. teor. Fiz.*, **26**, *No.* 2, 228–33 (1954) *In Russian.*

The variation with the angle of incidence of the coefficient of ellipticity and of the phase difference between the components in light reflected close to the Brewster angle from the surfaces of various organic liquids has been studied. The possible reasons for divergences between the results and the predictions of existing theory are discussed. R. C. MURRAY

535.55

10987. The photoelastic properties of short-chain molecular networks. L. R. G. Treloar. *Trans Faraday Soc.*, **50**, 881–96 (*Aug.*, 1954).

The mechanical and optical properties of a cross-linked amorphous polymer network are developed on the basis of the non-Gaussian statistical theory. Two models are considered, the tetrahedral (4-chain) model of Flory and Rehner and the more general model of Kuhn and Grün, in which the whole assembly of chains is included. It is shown that the general form of the dependence of stress and of optical anisotropy (i.e. birefringence) on strain is insensitive to the details of the model; there is, however, some variation in the maximum extensibility of the network. An approximate algebraic expression for the optical anisotropy, valid for all values of strain up to the maximum extension of which the network is capable, is included, but a correspondingly accurate expression for the stress is not obtainable, owing to the fact that the ultimate stress tends to infinity. A.

535.55 : 538.566

10988. On linearly polarized electromagnetic waves of arbitrary form. A. Nisbet and E. Wolf. *Proc. Cambridge Phil. Soc.*, **50**, *Pt* 4, 614–22 (1954).

Two simple laws connecting the amplitude and phase functions of a monochromatic electromagnetic wave of arbitrary form are derived, holding in the case when one of the field vectors is linearly polarized. The first is a generalized Fermat's principle which enables determination of the phase when the amplitude is known; the second expresses the propagation of the (vector) amplitude along the curves orthogonal to the co-phasal surfaces. Some other general properties of linearly polarized fields are also discussed, and illustrative examples are given. A.

535.64

10989. Orthogonal color-mixture functions. D. L. MacAdam. *J. Opt. Soc. Amer.*, **44**, 713–24 (*Sept.*, 1954).

Spectrophotometric curves uniquely determined by every set of colour specifications can be based on a Fourier-type analysis, using normal and orthogonal colour-mixture functions. Normal and orthogonal colour-mixture functions are convenient for the investigation of the propagation of errors in spectrophotometric colorimetry. The space based on normal and orthogonal colour-mixture functions serves as a suggestive model for the as yet unavailable visually homogeneous colour space, in which visual thresholds of colour shall be represented by equal-size spheres, at least for some fixed conditions of adaptation. Recent puzzling results of investigations of colour discrimination and heterochromatic photometry can be explained in a straightforward manner in terms of general properties of visually homogeneous colour space. Those properties are independent of the detailed structure of that space and are exemplified, though probably in a simplified manner, by the colour space based on normal and orthogonal colour-mixture functions. A.

535.65

10990. Automatic photoelectric colorimeter for direct reading of Munsell coordinates. G. L. GIBSON AND D. A. NEUBRECH. *J. Opt. Soc. Amer.*, **44**, 703–12 (*Sept.*, 1954).

A tristimulus photoelectric colorimeter enabling measurements to be made in terms of Munsell colour space is described. The instrument has been designed to read approximate hue, value and chroma directly upon three potentiometer dials. To accomplish this, readings of Adams *a* and *b* are obtained and converted into polar co-ordinates by the instrument after transformation into a uniform colour space. The new colour space is described. Results on actual renotated Munsell papers are discussed, and it is shown that specimens and standard must be similar in hue, value and chroma as well as spectral characteristics for satisfactory results. A.

535.65

10991. A regular rhombohedral lattice sampling of Munsell renotation space. G. WYSZECKI. *J. Opt. Soc. Amer.*, **44**, 725–34 (*Sept.*, 1954).

If the adjusted space is perceptually uniform, the rhombohedral sampling will result in an array of colours each of which, in the interior of the array, is surrounded by 12 nearest neighbours all differing from the central colour by the same perceptual amount. On this account this array of colours is maximally convenient for a closing visual check of the adequacy of the experimental data used for adjusting the colour space. As a first step toward production of such an array of colours in chip form, colour specifications were computed for a sampling of Munsell renotation space according to a rhombohedral space lattice of such unit size as to produce, with available colorants, about 500 colours. This paper gives the numerical results, together with a brief discussion of space lattices and their importance in studies of tridimensional colour spacing. A.

535.65 : 535.33.07

Tristimulus colorimeter designed for teaching and research. *See Abstr.* 10931

535.7 : 612.84

Physiological optics. *See Abstr.* 11682–6

535.81

10992. Testing of large optical surfaces with small test plates. J. B. SAUNDERS. *J. Res. Nat. Bur. Stand.*, **53**, 29–34 (*July*, 1954).

A procedure for testing large optical surfaces with relatively small optical standards is described. Simplified formulae are used to apply a statistical method for obtaining increased precision. A practical example is used to illustrate the procedure for testing surfaces that may be assumed to have revolution symmetry. A.

535.81

10993. Method for producing replica mirrors with high quality surfaces. G. HASS AND W. W. ERBE. *J. Opt. Soc. Amer.*, **44**, 669–71 (*Sept.*, 1954).

A method for improving the surface quality of replica mirrors is described. The method eliminates the generally used replica finishing or coating processes which may impair the optical precision of replica optics. With the new technique, the final mirror coatings are evaporated on to the master mould and separated with the replica body to which they adhere excellently. Thus no finishing coatings are required after the replicas are separated from the master mould. The method can be applied to plastic and electro-formed metal reproductions. Epoxy type resins were found to be especially suitable for making replicas of various optical elements. A.

535.81

10994. Measurement of contrast transmission characteristics in optical image formation. P. LINDBERG. *Optica Acta*, **1**, 80–9 (*Sept.*, 1954).

A method of testing the performance of lenses is worked out, based upon the fact that the light distribution in the image of any one-dimensional test pattern can be determined from the light distribution in the image of a line source, by an integration process. An optical integrator is constructed in which the object light distribution curves for certain appropriately chosen test patterns have been drawn on interchangeable slides and the corresponding image light distribution curves are measured with a photocell coupled to a paper recorder. Suggestions are made for a new terminology concerning the specification of lens performance. By means of another optical integrator, which is also described, the contrast transmission characteristics of the lens may be recorded directly. The interpretation of the characteristics so obtained is given, and it is shown how they may be used to calculate the image of an arbitrary test object, by a method involving Fourier transforms. A.

535.822.17

10995. Experimental studies of edge effect and contrast in phase microscope. I. S. NAWATA. *Sci. Rep. Res. Insts Tôhoku Univ. A*, **6**, 288–95 (*June*, 1954).

A phase microscope with a cross-shaped diffraction plate and condenser diaphragm of the same type was constructed. The edge effect and the contrast of the amplitude gratings with various structure constants were studied; a special eccentric diffraction plate was made, and it was observed that the edge effect could reach maximum value by the use of a plate with proper eccentricity. This special diffraction plate can be used effectively in the observation of samples with direction (for instance, fibres, scratches, track of particles, etc.). The results observed are as follows: (1) In the case of a diffraction plate with absorption only, the contrast increases and gradually comes up to a constant as the transmittance grows. On the other hand, the larger the transmittance grows, the smaller the edge effect becomes, and it disappears at a transmittance of 50 ~ 60%. (2) In a diffraction plate with fixed absorption and retardation, the contrast is affected by the width of the conjugate area and by the structure constants. The larger the width grows, the larger the edge effects grow, and these are the same for all structure constants. A.

HEAT 536

536.2.01 : 518.4

Two-dimensional non-stationary fields of the equation of thermal conduction. *See Abstr.* 10720

536.21 : 536.7

10996. Stationary temperature distribution in an electrically heated conductor. C. A. Domenicali. *J. appl. Phys.*, **25,** 1310–11 (*Oct.*, 1954).

The thermodynamic theory of irreversible processes as developed by Onsager, de Groot and Callen is used to derive in a straightforward way the partial differential equation for the stationary temperature distribution in an electrically heated, chemically inhomogeneous conductor. It is shown that the form of this differential equation given in 1900 by Diesselhorst (for homogeneous media) in terms of the electrical potential gradient $\nabla\phi$ is incorrect. Diesselhorst's equation reads $\nabla\cdot\kappa\nabla T + \sigma\tau\nabla T\cdot\nabla\phi + \sigma(\nabla\phi)^2 = 0$, in which κ is the thermal conductivity (for zero electrical current), T the temperature, σ the isothermal electrical conductivity, and τ the Thomson coefficient. The correct form of the equation, for the special case of a chemically homogeneous conductor, is $\nabla\cdot\kappa\nabla T + (1/\sigma)J^2 - \tau\mathbf{J}\cdot\nabla T = 0$, where $\mathbf{J}$ is the electrical current density. The correct form can be obtained by Diesselhorst's equation by substitution of the "isothermal Ohm's law" $J = -\sigma\nabla\phi$, which, however, is not valid in a non-isothermal medium. The apparent difficulty is resolved by the method of Onsager–de Groot–Callen, and it is shown that the correct differential equation expressed in terms of electrical potential is much more complicated than the form given by Diesselhorst. A.

536.21 : 548

10997. Low-temperature thermal conductivity of a Canadian natural graphite. A. W. Smith. Letter in *Phys. Rev.*, **95,** 1095–6 (*Aug.* 15, 1954).

Experimental values of the thermal conductivity of three flakes ($\frac{1}{4}\times\frac{1}{20}\times\frac{1}{100}$in.) of natural graphite measured in vacuo for the temperature range 3·5 – 350°K are shown graphically. The apparatus used is briefly described. The graphite samples had slip lines on the surface indicating crystallites of the order of 10^{-2} cm. Maxima of the conductivity occur at about 80°K and all three samples show a T^2 dependence of the conductivity at low temperatures. S. WEINTROUB

536.21 : 548.7

10998. The thermal conductivity of germanium and silicon at low temperatures. H. M. Rosenberg. *Proc. Phys. Soc.* [*London*] *A*, **67,** 837–40 (*Sept.*, 1954).

The thermal conductivity of a single crystal of Ge and a polycrystalline specimen of Si have been measured in the range 2 to 100°K. Both specimens were very pure. The results indicate that, at low temperatures at least, the lattice waves are not scattered by the conduction electrons, but that their mean free path is limited either by the size of the specimen (for the germanium) or by the crystallite size (for the silicon). A.

536.212.2 : 537.311.31 : 536.48

10999. The thermal and electrical conductivity of copper at low temperatures. G. K. White. *Austral. J. Phys.*, **6,** 397–404 (*Dec.*, 1953).

Measurements have been made of the thermal conductivity from 2 to 160°K and the electrical conductivity from 1·4 to 293°K of copper in strained and annealed states. From the results it is concluded that: (i) departures from the additive resistance hypothesis occur for both the thermal and the electrical resistance; (iii) whereas the values for "ideal" electrical resistivity, assumed due to scattering by lattice vibrations, are well represented by the theoretical relation $\rho_i = CT^5\ (T < \Theta/10)$, those for the ideal thermal resistivity require an expression $W_i = BT^{2\cdot 1}\ (T < \Theta/5)$ rather than the theoretically derived expression $W_i = BT^2$; (iii) an anomalous increase in the product of the thermal resistance and temperature occurs at low temperatures ($T <$ 5°K), which is possibly related to the minimum in the residual electrical resistance. A.

536.253

11000. The relation between the heat transfer and the convection phenomena in enclosed plane air layers. M. Jakob. Letter in *Appl. sci. Res. A*, **4,** *No.* 5–6, 459 (1954).

Comments on de Graff and van der Held's paper [Abstr. 5531 (1954)]. It is suggested that one reason for the deviation of their results from those of Mull and Reiher is that a correction for any heat flow in or on the glass plates surrounding the air layers was not made. The attack on the correctness of Jakob's formula for the heat transfer for vertical air layers is considered to be unnecessary. S. WEINTROUB

536.253

11001. The relation between the heat transfer and the convection phenomena in enclosed plane air layers. E. F. M. van der Held and J. G. A. de Graaf. Letter in *Appl. sci. Res. A*, **4,** *No.* 5–6, 460–1 (1954).

The authors reply to Jakob's criticisms (preceding abstract) and maintain that in comparing the results of different experimenters it is important to ascertain that the Grashof numbers have been correctly calculated. S. WEINTROUB

536.413.2.08 : 539.215

11002. A combined dilatometer and electrical resistivity apparatus for studies in powder metallurgy. N. A. McKinnon. *J. sci. Instrum.*, **31,** 383–5 (*Oct.*, 1954).

An apparatus to measure the change in linear dimensions and electrical resistivity of pressed compacts of metal powders is described. The expansion and contraction of the compact are measured by a dial gauge relative to silica comparison rods, while the electrical resistance is obtained by measuring the potential drop along a portion of the bar when a known current is flowing. Some typical results are given. A.

536.421.1

11003. The melting of gallium. J. Jach and F. Sebba. *Trans Faraday Soc.*, **50**, 226–31 (*March*, 1954).

By a differential thermal analysis method, and a very slow heating rate, it has been shown that the melting of gallium does not occur at a sharp melting point but extends over a range of temperature, the temperature of the gallium rising discontinuously, indicating that there are stages in the melting corresponding to melting occurring separately in different crystallographic directions. A.

536.423.15 : 539.155.2

11004. The vapour pressures of isotopic substances. I. Boron trichloride. M. Green and G. R. Martin. *Trans Faraday Soc.*, **48**, 416–21 (*May*, 1952).

Natural boron trichloride was investigated in a packed fractionating column of high efficiency to determine the relative volatilities of the isotopic boron chlorides. An equilibrium constant of 0·9982 has been deduced for the exchange,

$$B^{10}Cl_3\,(liq) + B^{11}Cl_3\,(g) \rightleftharpoons B^{11}Cl_3\,(liq) + B^{10}Cl_3(g)$$

compared with a value of 1·014 predicted for this system from a statistical calculation. Estimation of the B^{10} concentration was effected by measuring the slow neutron transmission of standard samples. Any uncertainty in the estimation of the number of equivalent plates in the column was eliminated by making measurements of the fractionation obtained with different rates of withdrawal of enriched material from the column; from such data the column platage and the volatility ratio have both been obtained. A.

536.432.15 : 541.182.2

11005. A direct test of Kelvin's equation connecting vapour pressure and radius of curvature. V. K. La Mer and R. Gruen. *Trans Faraday Soc.*, **48**, 410–15 (*May*, 1952).

Although Kelvin's relation (1871) predicting the increase in vapour pressure with increasing curvature is basic to colloid science, e.g. phenomena of capillarity, production and stability of colloidal systems, etc., no unambiguous direct experimental confirmation has ever been obtained. Its acceptance has rested upon the thermodynamic cogency of the derivation and the success of theories based upon it. The direct verification described is based upon an extension of the growth method of measuring the radii of monodisperse aerosol droplets initially too small for accurate determination by light scattering methods. The test involves measuring the extent to which the Kelvin relation controls under equilibrium conditions the growth of monodisperse non-volatile aerosol droplets when exposed to the vapours of a master solution consisting of the non-volatile component plus an excess of a volatile miscible solvent. Excellent quantitative confirmation has been obtained for the systems dioctyl phthalate + toluene and oleic acid + chloroform. A.

536.46

11006. The structure of flames. J. W. Linnett. *Sci. Progr.*, **42**, 419–34 (*July*, 1954).

An account of the progress that has been made in the study of simple flames during the last ten or twenty years. It is apparent that, even with simple flames, there are many outstanding problems at the present time. With more complex systems, such as turbulent flames, understanding is very limited indeed, involving, as it does, the solution of most difficult aerodynamic and chemical problems. A.

536.461

11007. Transition of the slow-rate combustion into detonation. K. I. Shchelkin. *Zh. éksper. teor. Fiz.*, **24**, *No.* 5, 589–600 (1953) *In Russian.*

Discusses the two fundamental ways of propagation of combustion in gaseous mixtures from one layer to another, due (1) to conduction and diffusion, and (2) to compression in a shock wave (detonation). The elementary theory of transition from slow combustion to detonation is set forth; it is shown that the pre-detonation acceleration of combustion in pipes is mainly caused by the effect of the motion of the non-burned gas and, in the first place, by the effect of its turbulence on the velocity of the flame propagation. The distance between the starting-point of the flame and the detonation point is found to be proportional to $c_0^2 D/C^n k^m(\pi - 1)^m u_n^2$, where c_0 is the velocity of sound in a non-turbulent gas; D, the pipe diameter; C, a factor equal to the area ratio of the flame front surface to the cross-section of the pipe; k, the degree of turbulence; π, the ratio of gas volumes before, and after, combustion; and u_n, the normal flame velocity. The exponents n and m are 4 and 3 for weak turbulence, and 3 and 2 for strong turbulence, respectively. F. LACHMAN

536.48 : 532.122

11008. Quantum effect in compressed liquid hydrogen. S. D. Harman. Letter in *J. Amer. Chem. Soc.*, **76**, 4244 (*Aug.* 20, 1954).

Comments on paper by Johnston, Keller and Friedman [Abstr. 7369 (1954)].

536.48 : 539.11

11009. The specific heat of metals at low temperatures. M. J. Buckingham and M. R. Schafroth. *Proc. Phys. Soc.* [*London*] *A*, **67**, 828–36 (*Sept.*, 1954).

The free energy of an electron gas interacting with lattice vibrations is calculated. The linear term in the low-temperature specific heat contains a factor depending on the strength of the interaction. The result is compared with recent experiments and suggestions for new investigations are discussed. A.

536.48

11010. On the Bose–Einstein liquid model for liquid helium. III. Further considerations regarding vapour pressures of He^3–He^4 mixtures. Z. Mikura. *Progr. theor. Phys.*, **11**, 244–50 (*March*, 1954).

For Pt II, see Abstr. 9190 (1954). Discontinuities at the λ-point in the temperature derivatives of vapour pressures of a He^3–He^4 mixture, which were predicted by deBoer and Gorter, have been thought not to be found in the existing experimental results. Reexamination of these data, however, reveals that the partial vapour pressure of He^3 has a break when it is plotted as a function of temperature. Both the deBoer–Gorter–Taconis and the "modified Bose–Einstein liquid" theories agree with experiment with respect to this point, in contrast to the Heer and Daunt theory. Below the λ-temperature, the "modified B.E. liquid" theory gives the partial pressure of

He^3 in qualitatively good agreement with experiment, but above this temperature neither theory agrees with experiment even qualitatively. The temperatures at which these discontinuities occur in experiment are, however, always considerably higher than the λ-temperatures expected from the experiment on superflow in mixtures. A.

536.48

11011. Annihilation of positrons in liquid helium. F. L. HEREFORD. Letter in *Phys. Rev.*, **95**, 1097–8 (*Aug.* 15, 1954).

Recent measurements of the rates of three-photon annihilations of positrons stopping in liquid nitrogen and Freon have been interpreted as indicating the absence of appreciable triplet positronium in the liquids. Similar results have now been obtained, by a different technique, concerning the presence of triplet positronium in liquid He. F. E. HOARE

536.48

11012. On Feynman's theory of liquid helium. H. N. V. TEMPERLEY. *Proc. Phys. Soc.* [*London*] *A*, **67**, 901–8 (*Oct.*, 1954).

It is shown that Feynman's proof of the existence of a generalized Bose–Einstein condensation in liquid helium can be carried through on the basis of fewer and less restrictive assumptions than he actually makes. The underlying physical idea proves to be very similar to those put forward by a number of other workers. His treatment using a Bijl wave-function is also examined, and it is concluded that the resulting energy-spectrum may very well be nearly correct, in spite of the fact that it does not agree numerically with that assumed in the present form of the Landau–Khalatnikov theory. Some serious difficulties in the latter theory seem to call for an adjustment of the parameter Δ to a larger value. This is in just the direction needed to improve the agreement with Feynman's theory. A.

536.48

11013. Film flow and bulk formation of helium II in capillaries. R. V. DYBA, C. T. LANE AND C. H. BLAKEWOOD. *Phys. Rev.*, **95**, 1365–8 (*Sept.* 15, 1954).

The formation and maintenance of bulk liquid in capillaries caused by the mobile film flowing from a liquid helium II bath below the capillaries has been observed. Experiments with parallel plates, cylindrical capillaries and annular capillaries indicate that bulk will form initially only when the width of the capillary space is below some critical value, depending on the geometry. However, bulk liquid once present in a capillary will be maintained by the film even if the width is greater than the critical value for initial formation. Measurements of film flow rates and equilibrium capillary rise in these capillaries give values in agreement with measurements of these quantities, under other experimental conditions, made by various other observers. The effects observed are discussed in terms of the known properties of liquid helium II. A.

536.531

11014. A copper resistance temperature scale. T. M. DAUPHINEE AND H. PRESTON-THOMAS. *Rev. sci. Instrum.*, **25**, 884–6 (*Sept.*, 1954).

Fine commercial copper wire, attached with Formel varnish to a copper base, has sufficiently stable and reproducible resistance temperature characteristics to be used as a resistance thermometer in the temperature range 20°–320°K. Excellent thermal contact is achieved by this construction; hence, unusually large heat inputs to the thermometer can be tolerated. Resistance and temperature coefficient of resistance are tabulated and limitations of accuracy discussed. A.

536.531 : 537.3

11015. Considerations on the practical realization of a "background noise" thermometer. R. AUMONT AND J. ROMAND. Letter in *J. Phys. Radium*, **15**, 585–6 (*July–Aug.–Sept.*, 1954) *In French.*

"Background noise" in a conductor can be used to measure the temperature particularly under high pressures. Apparatus and technique have been described elsewhere [Abstr. 2425 (1950); *Rev. gén. Elect.*, **62**, 210–16 (*April*, 1953); Abstr. 3583 B (1953); Abstr. 9203 (1954)]. This letter covers several points relating to the amplifier and other equipment used with particular reference to the reduction of their background noise. E. H. DOCK

536.631 : 536.21

11016. The specific heat and thermal conductivity of graphite. P. G. KLEMENS. *Austral. J. Phys.*, **6**, 405–9 (*Dec.*, 1953).

The specific heat of graphite is discussed in terms of a modified Debye treatment. It is shown that the contribution from the longitudinal waves varies as T^3 below 45°K, and as T^2 at higher temperatures, whereas the usual two-dimensional treatment leads to a T^2 variation at all low temperatures. Similarly the transverse contribution varies as T^3 at lowest temperatures, but above 10°K it varies as T^2. The temperature variation of the thermal conductivity differs from the variation of the specific heat, even though the thermal resistance arises from boundary scattering. This is explained in terms of a mean free path for waves in the hexagonal plane, which is considerably larger for longitudinal than for transverse waves, resulting in an increased contribution of the former to the thermal conductivity. A.

536.631 : 536.48

11017. Specific heats of metals below one degree absolute. J. RAYNE. *Phys. Rev.*, **95**, 1428–34 (*Sept.* 15, 1954).

The heat capacities of a number of metals have been measured in the region below 1°K, using the technique of adiabatic demagnetization. Copper, silver, platinum, palladium, tungsten, molybdenum and sodium have been investigated. Apart from sodium, all exhibit a linear dependence of electronic specific heat on temperature. The values of γ are in agreement with those obtained in the liquid helium region, except in the case of tungsten, which gives $\gamma = 3{\cdot}5 \pm 0{\cdot}2 \times 10^{-4}$ cal/mole deg^2 in contrast to the previous value $\gamma = 1{\cdot}8 \pm 0{\cdot}7 \times 10^{-4}$ cal/mole deg^2 reported in the literature. Sodium exhibits an anomalous peak in its specific heat curve. A low-temperature, martensitic-type transformation is advanced as a likely cause of this behaviour. In the course of the experiments, an independent measurement of the heat capacity of copper potassium sulphate was made. The relation $C = A/T^2$ appears to be obeyed, the value of the specific heat constant A being $5\cdot8 \pm 0\cdot2\times10^{-4}R$ deg^2/mole. A.

THERMODYNAMICS 536.7/.8

536.7

11018. Thermodynamic stability. I. Prigogine and H. C. Mel. *Bull. Acad. Roy. Belgique Cl. Sci.*, **40,** *No.* 6, 588–99 (1954) *In French.*

Classical discussion of the stability of thermodynamic equilibria has generally been based on the existence and properties of thermodynamic potentials such as Gibbs' free energy, etc. More recently another criterion of stability has been introduced, based on the sign of the entropy production caused by a perturbation in the system. This latter criterion also remains valid in cases for which no thermodynamic potential exists. Some of its consequences are discussed, and in particular, comparison is made with the general conditions of stability for the solutions of the corresponding differential equations (the rate equations). It is shown that the stability criterion based on the sign of the entropy production must be supplemented by the principle of microscopic reversibility (i.e. Onsager reciprocal relations) in order to assure asymptotic return of the perturbed system to its initial equilibrium position. A.

536.7

11019. Isotopic effects and thermodynamic properties in condensed phase. II. I. Prigogine and J. Jeener. *Physica*, **20,** 516–20 (*Aug.*, 1954) *In French.*

The method developed in Pt I [Abstr. 9215 (1954)] is extended to real three-dimensional lattices. The zero-point energy is calculated for isotopic mixtures and pure isotopes. The results obtained for one-dimensional lattices are shown to remain qualitatively valid for three-dimensional lattices; however, the heat of mixing is smaller than in the one-dimensional case. The stable state at 0°K always requires a separation into pure isotopes. A.

536.7 : 537.3

11020. The thermomechanics of the electric current. J. E. Verschaffelt. *Bull. Acad. Roy. Belgique Cl. Sci.*, **40,** *No.* 6, 574–87 (1954) *In French.*

See also Abstr. 7389 (1954).

536.7 : 539.11

Thermodynamics of phase transitions in compressible solid lattices. *See Abstr.* 11256

ELECTRICITY 537

ELECTROSTATICS . DIELECTRICS 537.2

537.2 : 530.145

Quantum effects in the interaction between free electrons and electromagnetic fields. *See Abstr.* 10787

537.21 : 621.3.011.4

11021. The capacitance of an anchor ring. T. S. E. Thomas. Note in *Austral. J. Phys.*, **7,** 347–50 (*June*, 1954).

Formulae, tables and approximations, for calculation.

537.221

11022. On the triboelectric properties of various fabrics of synthetic fibres. E. Darmois and A. Marais. *Rev. gén. Elect.*, **63,** 413–15 (*July*, 1954) *In French.*

See Abstr. 6747 (1953) and 6586 (1954). Some studies are described of the generation of charge by friction on pure P.V.C. and certain fibre blends containing it. A. E. KAY

537.221 : 551.594.21

11023. Electric charges from ice friction. J. A. Chalmers. *J. atmos. terrest. Phys.*, **2,** *No.* 6, 337–9 (1952).

Experiments are described showing that, when ice is rubbed, the large fragments carry a negative charge, in agreement with the theory of Simpson and Scrase for thunderstorm electrification. The present experiments extend the results of Pearce and Currie since they show charge separation even in the absence of air blasts. A.

537.224

11024. On a computation of the capacity of a cube. W. F. Cahill and P. Davis. Note in *Math. Tables Aids Comput.*, **7,** 272–3 (*Oct.*, 1953).

A computation performed on SEAC gave a value of $0\cdot6835$ in fair agreement with that of Gross [Abstr. 3281 (1953)].

537.226.1.08

11025. A mixed-liquid method for the determination of the dielectric constant of solids. J. L. Pauley and H. Chessin. *J. Amer. Chem. Soc.*, **76,** 3888–90 (*Aug.* 5, 1954).

The applicability of the mixed-liquid method to the measurement of the dielectric constant of powdered solids was tested with several isotropic crystalline materials: potassium iodide, potassium chloride, sodium chloride and calcium fluoride. By measurements on single crystals and powdered crystals it was found that, within the limits of error (about 2%), neither the amount of powder present nor the physical size of the particles affected the final results. Measurements on the systems were made by a resonance method using substitution techniques to determine capacitance at constant temperature and frequency. The dielectric constants of standard benzene–nitrobenzene solutions of different compositions first were determined in a conventional concentric-cylinder cell. The capacity of each of these solutions then was measured in a rigid parallel-plate cell, and finally redetermined after the addition of the solid material. The intersection of the curves formed on a capacity-dielectric constant plot by the series of solutions containing the given solid determined the dielectric constant of this solid. A.

537.226.1.08 : 621.317.335.3 : 621.317.73

11026. Dielectric constant meter for dilute solutions. A. W. Henderson and D. Taylor. *Trans Faraday Soc.*, **49,** 92–5 (*Jan.*, 1953).

The circuit diagram of a permittivity meter for the measurement of dipole moments is described. It is based on the heterodyne beat principle, and the use of a precision condenser to match the capacitance of the liquid cell is avoided by calibrating the meter with benzene solutions of nitrobenzene of known permittivity. An accuracy of $\pm 0{\cdot}0002$ unit was attained over small permittivity ranges. A.

537.226.2

11027. Table of dielectric constants and electric dipole moments of substances in the gaseous state. A. A. Maryott and F. Buckley. *Circ. Nat. Bur. Stand., No.* 537, 29 *pp.* (1953).

Values of the dipole moments and other pertinent information are tabulated for approximately 350 substances in the vapour state. All values derived from measurements of dielectric constants have been recalculated by one of two systematic procedures in order to place the work of various investigators on a more comparable basis than exists in the literature. Values obtained independently from microwave spectroscopy and other methods are also included. Values of the dielectric constants recommended for reference purposes are listed for helium, hydrogen, oxygen, argon, air, nitrogen and carbon dioxide. These selected values were derived from a consideration of radio-frequency, microwave and optical data. A.

537.226.2 : 541.182.6

The shapes of particles from dielectric constant studies of suspensions. *See Abstr.* 11514

537.226.2

11028. The nature of ferroelectricity in Rochelle salt. K. N. Karmen. *Zh. éksper. teor. Fiz.*, **26**, *No.* 3, 370–6 (1954) *In Russian.*

The magnitude of electric charge flowing in the circuit at the time of placing (or removal) of electric or mechanical stress on a sample of Rochelle salt can be measured correctly only when the period of oscillation of the ballistic galvanometer is smaller than the time of establishing of polarization (or depolarization), or length of applied impulse. It is shown that the time delay cannot be attributed to any interlayers between electrodes and surface of crystal. The great length of time of processes occurring in Rochelle salt on establishing the field cannot be explained by existing theories of ferroelectricity. J. LUKASZEWICZ

537.226.2

11029. Influence of a magnetic field on the microwave dielectric constant of a liquid crystal. E. F. Carr and R. D. Spence. *J. chem. Phys.*, **22**, 1481–5 (*Sept.*, 1954).

The real and imaginary parts of the complex dielectric constant of the liquid crystal and normal liquid phases of *para*-azoxyanisole and *para*-azoxyphenetole have been measured at a frequency of 15 300 Mc/s. A static magnetic field applied to the sample is capable of producing large changes in the observed values of the complex dielectric constant. The extent of this effect depends on the orientation and intensity of the static magnetic field and on the temperature. A.

537.226.2

11030. On the dielectric properties and phase transformations of mixed crystal systems of the perovskite type. H. Gränicher and O. Jakits. *Nuovo Cimento Suppl.*, **11**, *No.* 3, 480–520 (1954) *In German.*

Titanates of alkaline and rare earth metals were prepared and were examined by powder X-ray and dielectric measurement methods. The ferroelectric anomalies of $BaTiO_3$ remain even when mixed crystals with other perovskite titanates are formed. If the added material is itself ferroelectric (e.g. $SrTiO_3$) the Curie point and the transition temperature fall with increasing additive. Other anomalies are relatively unaffected. As a non-ferroelectric (e.g. KLa-titanate) is added Curie and transition points fall very much more steeply. The temperature dependence of the dielectric constant (ε) of $(Ca, Sr)TiO_3$ is anomalous in that ε has an unstable value at certain compositions and the temperature coefficient of ε is unstable at all compositions. Small alterations in crystal symmetry are associated with these anomalies. Using the model of S. Roberts [Abstr. 2761 (1950)] attempts were made to calculate the ferroelectric properties. ε for the unpolarized phases can be described by the Curie–Weiss law. A value of 10–30 is found for the constant part ε_0 of the expression $\varepsilon = \varepsilon_0 + C/(T - \theta)$. A. L. MACKAY

537.226.3 : 621.3.014.3 : 621.315.616.96

11031. Direct-current transients in polymethyl methacrylate and in polystyrene. P. Ehrlich. Letter in *J. appl. Phys.*, **25**, 1056–8 (*Aug.*, 1954).

Absorption currents are observed throughout the time range 1 to 10^4 sec, the steady-state conductivity being only a small fraction of the smallest transient value. Values of dielectric loss at 10^{-3} and 10^{-2} c/s, calculated from the transient conductivity [Abstr. 3152 B (1952); *Proc. Instn Elect. Engrs, IV*, **99**, 151–5 (*July*, 1952)] are compared with values measured at 10^2 and 10^3 c/s. With polystyrene there is little variation for the whole range, but with polymethyl methacrylate the loss angle decreases 20-fold from 10^2 c/s to 10^{-3} c/s. J. H. MASON

537.226.33

11032. On the time of relaxation of some organic molecules in pure liquid state. D. K. Ghosh. *Indian J. Phys.*, **28**, 191–9 (*April*, 1954).

The absorption of u.h.f. radio waves in the range 250–920 Mc/s and $3{\cdot}18$ cm microwaves in benzyl alcohol, benzyl chloride and benzyl amine has been studied by the direct optical method by avoiding formation of stationary waves. Maximum absorption of $3{\cdot}18$ cm microwaves was exhibited by benzyl alcohol, benzyl chloride and benzyl amine at temperatures 55°c, −15°c and −20°c respectively, and these are assumed to be due to rotation of the substituent groups about a diameter of the benzene ring passing through the point of substitution. In the u.h.f. region in the case of benzyl chloride peaks have been observed at 400 Mc/s at 28°c and at 790 Mc/s at 25°c which are due to dimers and monomers respectively. Similarly, in the case of benzyl amine a peak due to dimer at 275 Mc/s at 25°c and a peak due to monomer at 700 Mc/s at 0°c have been observed. In the case of benzyl alcohol absorption maxima have not been observed in this region, but indication of the existence of a maximum beyond 850 Mc/s has been observed. The radius of the rotor in this case comes out too low to be that of the molecule. In all the cases the absorption peaks in the u.h.f. region shift with change of temperature according to Debye's theory. The results obtained show that in these substituted benzenes the time of relaxation has different discrete values in each case and the occurrence of "effective time of relaxation" postulated by Fisher is corroborated by these results. A.

537.226.33

11033. Dielectric relaxation in cellulose containing sorbed vapors. R. Seidman and S. G. Mason. *Canad. J. Chem.*, **32**, 744–62 (*Aug.*, 1954).

The dielectric constant and dielectric loss factor were measured in a dispersion region for a paper of high cellulose content. The complex arrangement of the paper in the measuring condenser did not effectively alter the position of the dispersion region of the paper itself, as shown by electrical analysis. From this analysis equations were derived from which the dielectric constant and maximum dielectric loss factor of the cellulose fibre were evaluated for varying amounts of sorbed water, methanol and ethanol. The effect of each of these vapours on the position of the dispersion region was studied, measurements being performed over a range of frequency of 10 to 1000 kc/s, and a range of temperature of −58 to 26°c. A typical plasticizing action was observed in all three cases. This was confirmed from an analysis of the data using the theory of absolute reaction rates. A.

537.226.33 : 539.133

11034. The influence of molecular shape upon dielectric relaxation times. R. J. W. Le Fèvre and E. P. A. Sullivan. *J. Chem. Soc.*, **1954**, 2873–8 (*Aug.*).

Measurements are recorded of the relaxation times τ at infinite dilution of 32 different solutes, including methyl, *tert.*-butyl, phenyl, diphenylyl and naphthyl derivatives. Carbon tetrachloride is the solvent most frequently concerned. Correlations between τ and a number of properties of the solute are mentioned; the relationship of τ with mean polarizability multiplied by a "shape factor" is illustrated graphically. A.

537.226.33 : 539.133 : 532.13

Dielectric relaxation, viscosity and molecular shape. *See Abstr.* 10840

537.226.8

11035. Investigation of lasting polarization processes in glass at temperatures up to 70°C. M. S. Kosman and R. T. Paranyuk. *Zh. éksper. teor. Fiz.*, **24**, *No.* 6, 721–9 (1953) *In Russian.*

Presents graphed results of investigations on the electric properties of glass at room temperature, conducted by using the following methods: (1) transverse electric field [cf. Abstr. 8736 (1950) and 6945 (1951)] applied to Te films (on mica and glass); (2) self-discharge of the individual elements of an equivalent system; (3) direct determination of the polarization capacities; and (4) probe measurements. It has been found that (*a*) charges induced on condenser plates may decrease although polarization charges in the dielectric remain unchanged, (*b*) the transverse-field method enables the lasting polarization processes to be determined in glass at relatively low temperatures (17–47°c), and (*c*) the conductivity of both the glass and α-Ag_2S may be of electronic nature because the large low-voltage polarization capacities revealed cannot be attributed to ionic processes. F. LACHMAN

537.226.8 : 537.529 : 548.7

11036. Space charge effects in dielectric breakdown of solids. Y. Inuishi and T. Suita. *Technol. Rep. Osaka Univ.*, **3**, *Paper* 80, 269–74 (*Oct.*, 1953).

Time effects in dielectric breakdown of single crystals were studied, particularly in connection with space charge and partial breakdown. In KCl remarkable space-charge effects appear; this behaviour is explained by considering charged imperfections and spatial inhomogeneities. In contrast to this, space-charge effect is poor in orthorhombic sulphur. A.

537.228

11037. Contributions to the theory of electrostatic forces on immersed bodies. R. Cade. *Proc. Phys. Soc.* [*London*] *B*, **67**, 689–704 (*Sept.*, 1954).

Using the principles of Brown's theory of electrostatic forces on immersed bodies [Abstr. 9451 (1951)], an amendment is made to this theory to take into account, on a classical basis, the electrical and mechanical properties of the boundary of the body. A significant new feature is the inclusion of boundary-viscosity which, far from being negligible, is the all-important entity in the mechanics of the problem. Negative results are obtained for the case of a continuous-potential boundary, but they are such as to show the prior need for the deduction in a rigorous theory. Positive results are obtained for a discontinuous-potential boundary, and in this case additional electrostatic and mechanical properties appear, of interest on their own merit. A.

ELECTRIC CONDUCTION . CURRENTS 537.3

537.311.1

11038. A new model for the Debye dispersion equations. J. R. Macdonald. Letter in *Phys. Rev.*, **91**, 412 (*July* 15, 1953).

Based on the theory of Abstr. 457 (1954).

537.311.1

11039. The development of conductivity and the external photoelectric effect in the transition from single atoms to a compact metal. H. Mayer and R. Nossek. *Z. Phys.*, **138**, *No.* 3–4, 353–62 (1954) *In German.*

Studies of the properties of very thin layers of potassium deposited in ultra high vacuum. The mean free paths of the conduction electrons are deduced. C. A. HOGARTH

537.311.1 : 539.11

11040. The behaviour of the totality of electrons of an insulator in an electric field. H. Volz. *Z. Phys.*, **138**, *No.* 3–4, 330–5 (1954) *In German.*

For a one-dimensional model it is shown that a far-reaching analogy exists between the behaviour of the mass centre of the totality of electrons in an insulator and that of a single electron in a metal, i.e. the "eqns. of motion" of the wave-number are formally the same, and the energetic behaviour is similar. Under the influence of the field, transitions from ground state to excited states, corresponding to free electrons, may become possible. F. ANSBACHER

537.311.31

11041. The electrical resistivity of Cu–Ni alloys and Matthiessen's rule. Y. SHIBUYA. *Sci. Rep. Res. Insts Tôkohu Univ. A*, **6**, 199–206 (*June*, 1954).

The electrical resistivity of copper-nickel alloys has been measured at the temperature-range from ordinary to liquid nitrogen temperature and the validity of Matthiessen's rule concerning the alloys having the compositions approaching copper has been examined. The results obtained are as follows. (1) Both resistivity *v.* composition curves obtained at 23°C and −183°C are approximately parabolic. (2) It has been ascertained that Matthiessen's rule does not hold in the case of Cu–Ni alloys adjacent to copper, i.e. $d\rho/dt$ is not constant with the change of nickel-concentration but changes linearly with it. (3) A plausible explanation based upon the conduction theory of electricity in metals has been given for the deviation from Matthiessen's rule. A.

537.311.31 : 548.7

11042. Interaction of electrons with grain boundaries. M. H. COHEN AND C. S. BARRETT. Letter in *Phys. Rev.*, **95**, 1094–5 (*Aug.* 15, 1954).

The suggestion is critically examined that the resistance minimum at ∼4·2°K, found by Blewitt *et al.* [Abstr. 5594 (1954)] in originally single crystals of high-purity Cu after recrystallization following cold work, is due to scattering or trapping of electrons at grain or mosaic boundaries. The failure of the experimental observations to match the theoretical predictions and the negative results of an experiment to detect the pressure on the grain boundaries which the scattering of electrons by them would produce, indicate that some imperfections other than grain boundaries are present in Blewitt's recrystallized specimens. Impurities are suggested. A. D. LE CLAIRE

537.311.31 : 621.317.331.029.6

11043. A method for the measurement of conductivity of metals at microwave frequencies. S. K. CHATTERJEE, P. R. SHENOY AND C. R. BAI. *J. Indian Inst. Sci. B*, **36**, 107–22 (*July*, 1954).

A theory has been worked out with the aid of field equations. An expression for the reflection coefficient in terms of voltage standing-wave ratio, attenuation constant, scattering coefficient of any waveguide discontinuity present in the system and phase factors has been derived. The values of conductivity for several metals obtained by this method agree well with the values obtained by other existing methods. A.

537.311.32 : 537.529

11044. On electric resistance in various crystallographic directions. A. A. VOROB'EV. *Zh. tekh. Fiz.*, **24**, *No.* 5, 848–50 (1954) *In Russian.*

The results of the investigation show that the theories of the electric breakdown, leading to the conclusion on the dependence of the electric resistance on the crystallographic direction, contradict the experimental data. The samples used were rock salt 20×20×20 mm cubes in which the diagonals of the grain or ribs of the cube from two opposite ends were recessed hemispherically and then polished. The breakdown occurred with pulses $\frac{5}{40}$ μsec wide, with the samples immersed in xylene or transformer oil. The maximum values of electric resistance in the direction of the grain diagonal $E_{100} = 1{\cdot}33$ MV/cm, for $E_{110} = 1{\cdot}29$ MV/cm and for $E_{111} = 1{\cdot}22$ MV/cm. The results of the investigation are presented in histograms. Z. F. WOJNAR

537.311.32 : 538.632

11045. Electrical properties of silicon containing arsenic and boron. F. J. MORIN AND J. P. MAITA. *Phys. Rev.*, **96**, 28–35 (*Oct.* 1, 1954).

Electrical conductivity and Hall effect have been measured from 10° to 1100°K on single-crystal silicon containing arsenic and boron. Extrinsic carrier concentration is computed from Hall coefficient. Analysis of extrinsic carrier concentration indicates the ionization energy of arsenic donor levels to be 0·049 eV and of boron acceptor levels to be 0·045 eV for low impurity concentrations. Fermi degeneracy is found to occur in the range 10^{18} to $10^{19}\,\mathrm{cm}^{-3}$ impurity concentration. Extrinsic Hall mobility is computed from Hall coefficient and conductivity. Curves of Hall mobility against resistivity at 300°K are computed from theory and compared with experiment. The temperature dependence of lattice-scattering mobility is found from conductivity to be $T^{-2\cdot6}$ for electrons and $T^{-2\cdot3}$ for holes. From conductivity mobility and intrinsic conductivity, it is found that carrier concentration at any temperature below 700°K is given by the expression: $np = 1{\cdot}5\times10^{33}T^3\exp(-1{\cdot}21/kT)$. The temperature dependence of the ratio Hall mobility/conductivity mobility is determined for holes and electrons. A.

537.311.33

11046. Band structure in disordered alloys and impurity semiconductors. H. M. JAMES AND A. S. GINZBARG. *J. phys. Chem.*, **57**, 840–8 (*Nov.*, 1953).

The band structure of a one-dimensional model of a disordered alloy, or of a crystal with randomly placed impurities, is treated by a method that takes full account of the random element of the problem, and does not involve the assumption that the deviation from periodicity is small. The method is based on the idea of counting the number of nodes in a solution of the wave equation with energy E, as a means of determining how many states of the system have energies lower than E. It requires solution of the wave equation only within a single cell of each type considered; thereafter, the calculation can be reduced to an algebraic form well adapted to machine calculation, or to a graphical form suited for the discussion of general properties of these systems. An illustrative calculation on a linear model shows how the sharply defined "impurity band" of a crystal with regularly placed impurities is replaced by a broadened region of high energy-level density when the impurities are randomly arranged. A.

537.311.33

11047. On the theory of conductivity in isotropic semiconductors. O. MADELUNG. *Z. Naturforsch.*, **9a**, 667–74 (*July–Aug.*, 1954) *In German.*

The classical theory of conductivity in semiconductors is discussed and the equations relating current flow, thermal gradients, and magnetic fields are derived. From these equations the coefficients of the thermoelectric, galvanomagnetic and thermomagnetic effects are obtained. For small magnetic fields a table of coefficients is given for degenerate and non-degenerate semiconductors. C. A. HOGARTH

537.311.33 : 537.312.5

11048. The direct conversion of β-irradiation energy into low-voltage electrical energy. W. M. LOMER. *Atomic Energy Res. Establ.* [*Harwell*] *Mem. T/M* 108, 11 + iii *pp. figs.* (1954).

A theory is presented which accounts for the observations [Abstr. 4519 (1954)] on the e.m.f. produced by a semiconductor junction under irradiation. It is shown that for high efficiency a semiconductor with a large energy gap, and with both *p* and *n* material as heavily doped as is practicable, should be placed in a very high irradiation density. The optimum thickness for the transistor is found to be when both *p* and *n* material are one or two diffusion lengths thick. Figures are given for possible efficiencies of Si and Ge, and show the former far superior; SiC may be even better if it can be produced in suitable form. The life-time of the battery will be determined by atomic displacements caused by the irradiation, and is a serious limitation. Any practical use would necessitate a compromise between long lifetime and high efficiency, which require respectively low and high irradiation density. A.

537.311.33 : 538.63 : 548.7

11049. Magnetoresistance effect in cubic semiconductors with spheroidal energy surfaces. M. SHIBUYA. *Phys. Rev.*, **95**, 1385–93 (*Sept.* 15, 1954).

The collision frequency of electrons having a spheroidal energy surface with acoustical modes of vibration is calculated without neglecting phonon energy. Using an asymptotic form in which the collision frequency is proportional to the square root of their energy, the electronic current in a semiconductor in combined magnetic and weak electric fields can be calculated in a closed form by the formal theory of conductivity. The magnetoresistance effect in oriented single crystals of *n*- and *p*-type germanium observed by Pearson and Suhl may be discussed consistently at least semiquantitatively with this calculation in both weak and strong magnetic fields. A.

537.311.33

11050. On slow changes of conductivity with time for CdS single crystals at high temperatures and under additional optical irradiation. A contribution to the clarification of the conduction-mechanism. K. W. BÖER, E. BORCHARDT AND W. BORCHARDT. *Z. phys. Chem.* [*Leipzig*] **203**, 145–62 (*Aug.*, 1954) *In German.*

It is found that the time variation of conductivity after irradiation or heating up is not of the expected similar form. Experiments on this effect are described including the dependence of the build-up and decay on temperature, light intensity, and previous heat treatment. Experiments analogous to the thermoluminescence glow curves are also described.

C. A. HOGARTH

537.311.33

11051. Effect of nickel and copper impurities on the recombination of holes and electrons in germanium. J. A. BURTON, G. W. HULL, F. J. MORIN AND J. C. SEVERIENS. *J. phys. Chem.*, **57**, 853–9 (*Nov.*, 1953).

Nickel and copper impurities are found to increase the rate of recombination of holes and electrons in germanium single crystals. The measured dependence of lifetime on resistivity at room temperature is consistent with the Shockley–Read–Hall theory of recombination at traps near the middle of the forbidden band. The capture cross-sections for holes and electrons have been estimated for these traps produced by nickel and copper. Additional evidence for such traps is also given by conductivity, Hall effect, photoconductivity and optical absorption measurements. Nickel or copper contaminations of the order of 10^{-10} atom fraction could account for the recombination rates observed in ordinary germanium crystals at room temperature. A.

537.311.33

11052. Changes of surface conductivity of germanium with ambient. S. R. MORRISON. *J. phys. Chem.*, **57**, 860–3 (*Nov.*, 1953).

The conductivity and the change in contact potential with illumination, $(\Delta\,\text{c.p.})_L$, have been measured in germanium as a function of the ambient atmosphere. The results have been compared with the measurements of Brattain and Bardeen on the contact potential of germanium as a function of ambient. It has been demonstrated that the conductivity changes observed can be correlated with changes in the space charge layer at the free surface of the semiconductor. A.

537.311.33

11053. Ionization energies of groups III and V elements in germanium. T. H. GEBALLE AND F. J. MORIN. Letter in *Phys. Rev.*, **95**, 1085–6 (*Aug.* 15, 1954).

From careful measurements of variations of Hall coefficient with temperature, significant differences are found for different added impurities.

C. A. HOGARTH

537.311.33

11054. Electron multiplication in germanium at low temperature. E. J. RYDER, I. M. ROSS AND D. A. KLEINMAN. Letter in *Phys. Rev.*, **95**, 1342–3 (*Sept.* 1, 1954).

Further experiments on the effect of changes in current density *I* with high fields *E* at low temperatures. Following a suggestion of Conwell, experiments were made on one *n*-type sample at 12·1°, 13·9°, and 20·3°K and showed the initial steep rise of *I* with *E* before the $E^{\frac{1}{2}}$ variation region was reached. The analysis of results confirms the multiplication explanation. C. A. HOGARTH

537.311.33 : 538.632

11055. Properties of zinc-, copper-, and platinum-doped germanium. W. C. DUNLAP, JR. *Phys. Rev.*, **96**, 40–5 (*Oct.* 1, 1954).

Hall effect and resistivity measurements have been made on a number of samples of single-crystal germanium containing additions of zinc, platinum, and copper. All three were found to be acceptors with energy of ionization 0·029, 0·040, and 0·036 eV electron volt, respectively. Measurements were made in the temperature range 15°K to about 400°K. All the Hall and resistivity curves showed a tendency to flatten out at the lowest temperatures, rather than to continue on an exponential curve. Possible explanations include (*a*) surface conductivity with low activation energy, (*b*) traces of low-ionization energy acceptors, (*c*) internal leakage due to imperfections or dislocations. Studies were made looking for acceptor states in the upper part of the forbidden band, such as have been found for gold. Evidence was found for a platinum acceptor level 0·2 eV below the conduction band and for a copper acceptor level just below the middle of the forbidden band. A.

537.311.33

11056. Thermal effects on lifetime of minority carriers in germanium. R. A. Logan and M. Schwartz. *Phys. Rev.*, **96**, 46 (*Oct.* 1, 1954).

Earlier work has shown that germanium may be heated to elevated temperatures (~ 875°c) without significant change in its room temperature resistivity, provided special care is taken to prevent chemical contamination. Such precautions were not sufficient, however, to prevent a drastic decrease in the minority carrier lifetime. In the present work it is shown that if, in addition to cleanliness, special precautions are taken to avoid the introduction of strains or plastic flow in the germanium crystal, minority carrier lifetimes in excess of 100 microseconds can be maintained after such heat treatments. A.

537.311.33

11057. The electrical properties of indium antimonide. II. O. Madelung and H. Weiss. *Z. Naturforsch.*, **9a**, 527–34 (*June*, 1954) *In German.*

For Pt I, see Abstr. 2431 (1954). Measurements of electrical conductivity and Hall coefficient of InSb samples containing different amounts of impurity over a temperature range from 175 to 750°K. For the width of the forbidden zone, a value of $(0{\cdot}27 - 3\times10^{-4}T)$ eV is found. The electron mobility is about $65\,000(T/300)^{-1{\cdot}66}$ cm^2/V sec, but the hole mobility is appreciably smaller and strongly temperature-dependent. InSb is degenerate at low temperatures and this must be considered in interpreting experimental results. A. E. DE BARR

537.311.33

11058. Electrical conductivity of magnesium oxide single crystals. E. Yamaka and K. Sawamoto. Letter in *Phys. Rev.*, **95**, 848–50 (*Aug.* 1, 1954).

Measurements by an a.c. method between 700 and 1000°C confirm that MgO is an impurity semiconductor, with a 2·37 eV energy level due to excess Mg, and no levels due to excess O, and that the carriers are positive holes. See also Abstr. 4798, 7682, 8411 (1953). J. HAWGOOD

537.311.33

11059. The instability of the electrical conductivity of selenium. R. Yu. Kaden. *Zh. éksper. teor. Fiz.*, **24**, *No.* 6, 714–20 (1953) *In Russian.*

Presents in graphed form the results of an investigation on the electrical conductivity (in the dark) of grey Se between 0 and 130°C. The specimens were prepared so as to exclude any possibility of contamination by halogens; after crystallization, they were subjected to a 2–3 hours' heat treatment at 210–215°C. It was found that, while between 100 and 130°C the dark conductivity rapidly attained a reproducible value, no constant value could be obtained for it at room temperature. When the specimen was cooled, its conductivity rapidly increased instead of falling off in accordance with the known exponential law; the increase of conductivity was reversible. The sign of the thermal e.m.f. showed that this anomalous conductivity was of electronic nature. When the cooled specimen was left to itself at constant temperature, the conductivity decreased in accordance with a hyperbolic relationship consistent with a bimolecular recombination mechanism of electrons and holes. F. LACHMAN

537.311.33

11060. Theory of electron multiplication in silicon and germanium. P. A. Wolff. *Phys. Rev.*, **95**, 1415–20 (*Sept.* 15, 1954).

Using methods similar to those employed to treat the gas discharge, a theory is developed to explain the multiplication of electrons (and holes) in Si and Ge junctions. The calculations take into account the effects of electron-phonon and pair-producing collisions on the distribution function. In Si, the only element for which complete measurements have been made, the calculated ionization rate *v.* field curve is in agreement with experiment if one assumes a mean free path of 200 Å for interactions between electrons and optical phonons. A.

537.311.33 : 538.63 : 548.7

11061. Electrical properties of tellurium crystals at very low temperatures (experiment with liquid helium). T. Fukuroi, S. Tanuma and Y. Mutô. *Sci. Rep. Res. Insts Tôhoku Univ. A*, **6**, 18–29 (*Feb.*, 1954).

The electrical conductivity, the Hall effect and the magneto-resistance effect are investigated with specimens of highly purified tellurium single crystal, and tellurium crystal with 0·01% antimony added, over the temperatures ranging from ambient to the liquid helium temperatures (1·7°K). The former specimen is found to be a *p*-type extrinsic semiconductor below 167°K, above which intrinsic excitation results. By analysing the data of conductivity and Hall coefficient, taking into account the scattering mechanisms of current carriers together with their degeneracy, and also by assuming the additivity of ionized impurity scattering, lattice scattering and dislocation scattering, the Hall mobility of holes μ cm^2/volt-sec is expressed by the formula: $1/\mu = 1/\mu_i + 1/\mu_l + 1/\mu_d = 5{\cdot}7\times10^{-3}T^{-3/2}\ln(1 + 3{\cdot}8\times10^{-2}T^2) + 5{\cdot}05\times10^{-7}T^{3/2} + 4{\cdot}0\times10^{-4}T^{-1}$, where μ_i is the mobility associated with the impurity scattering as calculated by Conwell and Weisskopf, μ_l is that corresponding to the lattice scattering and μ_d is that associated with the dislocation scattering which was treated by Dexter and Seitz. The corresponding term μ_n which is ascribable to the neutral impurity scattering seems to be negligibly small. Both the excitation energy required to raise an electron from the valence band to the acceptor impurity and the height of the electrochemical potential above the valence band are found to tend to zero as the temperature approaches to zero. A.

537.311.33 : 548.7

11062. The effect of thermally produced lattice defects on the electrical properties of tellurium. S. Tanuma. *Sci. Rep. Res. Insts Tôhoku Univ. A*, **6**, 159–71 (*April*, 1954).

The electrical properties of tellurium crystals are reinvestigated under the assumption of excess holes in the valence band owing to the trapping of electrons by the lattice defects generated by the thermal excitation of lattice atoms. From the observed data of the electrical conductivity and the Hall effect, and by applying the treatment of a composite semiconductor in which the extrinsic acceptors and the thermally produced acceptors both generate holes other than the intrinsic pair excitations of electrons and holes, the width of the forbidden energy band ΔE, the effective masses of electrons and holes m_e and m_h, and the carrier mobilities due to the lattice scattering μ_{eL} and μ_{hL} are determined as $\Delta E = 0{\cdot}32 + 1{\cdot}9 \times 10^{-4} T$ eV, $m_e = 0{\cdot}68m$, $m_h = 0{\cdot}91m$ and $\mu_{eL} = 2{\cdot}1\,\mu_{hL} = 6{\cdot}1 \times 10^6 T^{-\frac{3}{2}}$ cm^2/volt sec. The sign reversals of Hall effect and thermoelectric power from minus at lower temperatures to plus at higher ones found in the pure intrinsic region are explained by the predominance of holes released from the lattice defects the concentration of which increases with the rise of temperature, and the optimum fit of the calculated characteristics to the observed one is obtained by assuming the activation energy to produce one lattice defect as $0{\cdot}52$ eV. A.

537.311.33

11063. Capacitance measurements on alloyed germanium-indium rectifiers. H.-L. Rath. Note in *Naturwissenschaften*, **41**, *No.* 7, 161–2 (1954) *In German.*

Measurements of capacitance C *v.* reverse bias voltage U match the law $1/C^2 = \alpha(U + U_0)$ well over $0{\cdot}5$ to 50 volts, where α and U_0 are constants. The donor impurity concentration N in the germanium deduced from α and the junction area agrees well with that inferred from the bulk resistivity of the germanium over the range of N of 10^{14} to 5×10^{14} cm^{-3}. F. F. ROBERTS

537.311.33

11064. [Surface-] barrier contacts between germanium and evaporated metals. H.-U. Harten. Note in *Naturwissenschaften*, **41**, *No.* 7, 162 (1954) *In German.*

Au and Cu films evaporated in high vacuum on to *n*-type Ge produce rectifying contacts having capacitance *v.* reverse bias voltage characteristics similar to those for alloy type junctions (see preceding abstract), but the value of the constant α is $\frac{1}{4}$ of that expected from the resistivity of the germanium, for values of the latter over the range $0{\cdot}6$–22 Ω-cm with a specified surface pre-treatment. Other treatment can lead to different α values. F. F. ROBERTS

537.311.33

11065. Electronic behaviour of certain grain boundaries in perfect crystals. H. F. Mataré. *Z. Naturforsch.*, **9a**, 698 (*July–Aug.*, 1954) *In German.*

A preliminary study of the transistor action of high-resistivity grain boundaries in Si. With charge carriers injected in the crystallographically disturbed region, high values of $\alpha(\sim 50)$ are obtained. J. FRANKS

537.311.33

11066. Distribution of the mass transported from a collector into a germanium crystal by the forming process. M. W. Aarons, M. Pobereskin, J. E. Gates and E. B. Dale. Letter in *Phys. Rev.*, **95**, 1345 (*Sept.* 1, 1954).

Tungsten whiskers were plated with Au 199 and 197 and used to form contacts on 7 ohm cm germanium. It appears that there is a high density of Au at the surface, then less, and then higher again as we proceed into the crystal. C. A. HOGARTH

537.311.33 : 621.375.4

11067. Self-powered semiconductor amplifier. C. G. B. Garrett and W. H. Brattain. Letter in *Phys. Rev.*, **95**, 1091–2 (*Aug.* 15, 1954).

Consists of a slice of *n*-type Ge with an In-alloyed emitter and an electrolyte with an electrode more noble than Ge, say silver/silver oxide in N/10 KOH solution. Connecting the Ag and the Ge via a resistance leaves the germanium anodically biassed. The electrolyte collector has an intrinsic α of about $1{\cdot}4$ to $2{\cdot}0$. Power gain is obtained. Frequency-response compares favourably with conventional transistors of similar size. Since the collector is part of an electrolytic cell no external bias is needed. The power gain arises from the gradual electrochemical solution of the Ge. C. A. HOGARTH

537.311.33

11068. The effect of a transverse electric field on carrier diffusion in the base region of a transistor. J. S. S. Kerr, J. S. Schaffner and J. J. Suran. *J. appl. Phys.*, **25**, 1293–7 (*Oct.*, 1954).

A solution for the density of minority carriers is obtained for a semiconductor device having a two-dimensional rectangular geometry and a transverse field. The solution is developed for a variety of boundary conditions and the current-gain factor α of the corresponding semiconductor devices is obtained from this solution. A.

537.311.6 : 530.162

11069. Measurements on current noise in carbon resistors and in thermistors. K. M. van Vliet, C. J. van Leeuwen, J. Blok and C. Ris. *Physica*, **20**, 481–96 (*Aug.*, 1954).

Measurements are reported on carbon resistors and some related types (frequency range 2 c/s — $1{\cdot}2$ Mc/s) and on thermistors (2 c/s — 50 kc/s). For carbon resistors it was found that the noise spectrum in the whole range can be represented by $S(\nu) = Ai^2/\nu^a$, with $\alpha \simeq 1$, where i is the current and ν the frequency. This is in contrast to measurements of Campbell and Chipman (1949) and not in accordance with theories of Macfarlane (1950) and Petritz (1952). Measurements on thermistors showed that the current noise is extremely weak as compared with carbon resistors. The spectrum showed deviations from the $1/\nu$ dependence. The spectral density in the "$1/\nu$ part" of the spectrum is proportional to $i^{1{\cdot}2}$. This is in agreement with measurements of Brophy (1954). Some explanations are suggested for the other part of this spectrum. A.

537.312.5

11070. Role of deep traps in the formation of the photoelectric signal of thin layers of cadmium sulphide. G. Wlérick. *C.R. Acad. Sci.* [*Paris*] **239**, 257–9 (*July* 19, 1954) *In French.*

The rise of photoconduction with time in CdS is found to have a rapid and linear initial portion, followed by a second slower stage caused by filling of deep traps, with a final and more rapid rise due to increase of conduction electrons after saturation of the traps. G. F. J. GARLICK

537.312.5

11071. Photovoltaic effect in InAs. R. M. Talley and D. P. Enright. Letter in *Phys. Rev.*, **95**, 1092–4 (*Aug.* 15, 1954).

Thermoelectric tests located *p-n* junctions in carefully prepared ingots of InAs. Data is given for photo e.m.f. and transmission with wavelength at room and liquid nitrogen temperatures. The edge lies at about $4\cdot5\ \mu$. C. A. HOGARTH

537.312.5 : 539.11

11072. Energy levels and photoconductivity in electron-bombarded germanium. H. Y. Fan, W. Kaiser, E. E. Klontz, K. Lark-Horovitz and R. R. Pepper. Letter in *Phys. Rev.*, **95**, 1087–8 (*Aug.* 15, 1954).

Hall effect and photoconduction studies after bombardment with 4·5 MeV electrons at 100°K. From the results levels 0·21 eV above the filled band and 0·22 eV below the conduction band are deduced together with a possible level 0·11 eV above the filled band. Large photoconductivity has been measured in electron-irradiated samples well beyond the usual absorption edge. C. A. HOGARTH

537.312.6

11073. Electric resistance measurements on thin iron films. Temperature dependence of the resistance and deviations from Ohm's Law at low temperatures. S. R. Lambeir. *Verhandl. K. Vlaamse Acad. Wetensch.*, *No.* 40, 98 *pp.* (1953) *In Dutch.*

537.312.6 : 536.48

11074. The resistance-temperature characteristics of leaded brass wires at helium temperatures. D. H. Parkinson and J. E. Quarrington. Note in *Proc. Phys. Soc.* [*London*] *B*, **67**, 644–6 (*Aug.*, 1954).

A study of the effect of annealing on the temperature-sensitive range. E. H. SONDHEIMER

537.312.62

11075. On the superconducting state. J. G. Valatin. *C.R. Acad. Sci.* [*Paris*] **235**, 132–4 (*July* 16, 1952) *In French.*

537.312.62

11076. Determination of the structure factor of thin tin films from superconductivity measurements. A. Van Itterbeek, L. De Greve, L. Van Gerven and J. Schepers. *Nature* [*London*] **172**, 952 (*Nov.* 21, 1953).

537.312.62

11077. The structures of superconductors. II. The low-temperature decomposition of the metallic compound Au$_2$Bi. N. E. Alekseevskiĭ, G. S. Zhdanov and N. N. Zhuravlev. *Zh. éksper. teor. Fiz.*, **25**, *No.* 1(7) 123–6 (1953) *In Russian.*

For Pt I, see Abstr. 11530 (1954). Microscopic and X-ray powder investigations established that the superconductor Au$_2$Bi decomposes at low temperatures; this explains why a small displacement of the temperature of transition to the superconducting state is observed in specimens which have undergone hydrostatic compression. [For Pt III, see Abstr. 11564 (1954).] A. L. MACKAY

537.312.62

11078. Measurements on the superconductivity of thin layers of columbium, lead and tin. L. van Gerven and F. Heremans. *Verhandl. K. Vlaamse Acad. Wetensch.*, *No.* 42, 75 *pp.* (1953) *In Dutch.*

537.312.62

11079. Critical currents in the superconducting alloy Pb–Bi in applied magnetic fields. P. Grassmann and L. Rinderer. *Helv. Phys. Acta.*, **27**, *No.* 4, 309–12 (1954) *In German.*

The dependence of critical current in Pb + 10% Bi on longitudinal and transverse fields (up to a few thousand G) was not in accordance with Silsbee's hypothesis but proportionality of critical current to the wire diameter was approximately fulfilled.
D. SHOENBERG

537.312.62

11080. An attempt to treat the interaction between electrons and lattice vibrations. F. Takano. Note in *J. Phys. Soc. Japan*, **9**, 430–1 (*May–June*, 1954).

In Bardeen's theory of superconductivity [Abstr. 1846 (1951)] interelectron correlations were neglected, and the averaging over the normal modes of the lattice was ambiguous. A more rigorous calculation indicates that the system should be treated as a whole; an equation is derived for the electronic energy-level shift due to interaction with the lattice. It is similar to Bardeen's, though more complex. J. HAWGOOD

537.312.62

11081. Structure of the intermediate state in superconductors. A. L. Schawlow, B. T. Matthias, H. W. Lewis and G. E. Devlin. Letter in *Phys. Rev.*, **95**, 1344–5 (*Sept.* 1, 1954).

The domain structure of a tin disk in the intermediate state has been examined and photographed by covering the surface with superconducting niobium particles which migrate to the superconducting regions.
D. SHOENBERG

537.312.62

11082. Superconductivity of Nb$_3$Sn. B. T. Matthias, T. H. Geballe, S. Geller and E. Corenzwit. *Phys. Rev.*, **95**, 1435 (*Sept.* 15, 1954).

Intermetallic compounds of niobium and tantalum with tin have been found. The superconducting transition temperature of Nb$_3$Sn at 18°K is the highest one known. A.

537.312.62

11083. Adiabatic magnetization of a superconducting sphere. R. L. Dolecek. *Phys. Rev.*, **96**, 25–8 (*Oct.* 1, 1954).

Measurements are reported of the temperature changes accompanying suppression of the superconductivity of a lead sphere by adiabatic magnetization. Observations were made in the temperature range 2·1°K to 4·3°K for magnetizations into the complete range of the intermediate state. The magnetic fields were applied as step functions of time, and allowance was made for the resulting eddy-current heating. After magnetization, practically complete temperature equilibrium was established in the order of 15 sec. Temperature changes observed on magnetization were in quantitative agreement with values predicted from calorimetric data and demonstrate a linear relationship between the applied magnetic field and the fraction of normal metal produced in the intermediate state. A.

537.312.62 : 548.5

Preparation of superconducting crystals of Bi_3Ni. *See Abstr.* 11530

537.312.62 : 548.736

Crystal structures of superconducting alloys. *See Abstr.* 11564–7

537.32

11084. The effect of tension on the thermoelectric properties of metals. A. J. Mortlock. *Austral. J. Phys.*, **6**, 410–19 (*Dec.*, 1953).

Measurements have been made on 11 different metals of the change in thermoelectric power accompanying elastic tensile strain. The measurements were made over the temperature range 20–400°C on specimens of known purity. There is evidence that the magnitude of the general effect is dependent upon the purity of the specimen. The results obtained with gold differ considerably from those found by another observer. New approximate values of the general coefficients, which describe the first-order change in thermoelectric power for isotropic metals under all types of elastic strain, have been computed using the results obtained and the only available similar low pressure data. The new values suggest that recent conclusions regarding the position of the Fermi level for gold, silver and copper require modification. A.

537.32

11085. Thermoelectric power of pure and doped AgBr. L. Patrick and A. W. Lawson. *J. chem. Phys.*, **22**, 1492–5 (*Sept.*, 1954).

Measurements on the thermoelectric power of pure AgBr and AgBr doped with $CdBr_2$ have been interpreted in the light of the kinetic theories of Wirtz and de Groot. The ratio of the mobility of the interstitial silver ions to that of the vacancies as determined by Teltow is reasonably consistent with the data reported here on thermoelectric power. Estimates are given for the heats of transport of the various species of moving imperfections. No evidence of a contribution by Schottky defects to the thermoelectric power is found. A.

537.362

11086. Evaluation of true zeta potential of the particles of glass forming a diaphragm from measurements of streaming potential. B. N. Ghosh, B. K. Choudhury and P. K. De. *Trans Faraday Soc.*, **50**, 955–8 (*Sept.*, 1954).

It has been shown that it is possible to find the true ζ-value of Pyrex glass particles forming a diaphragm, in contact with solutions of different concentrations of KNO_3, from Wijga's experimental data by using an equation of the form $1/\zeta_a = 1/\zeta + m/r$, where ζ_a is the electrokinetic potential calculated from Smoluchowski's equation, m is a constant under the conditions of the experiments and r is found from χ, the specific surface conductivity of the diaphragm, from data on conductance measurements. A.

537.364

11087. Test of the theory of Overbeek and Wijga by measurements of streaming potentials on diaphragms and on diaphragm models. R. Janssen. *Meded. K. Vlaamse. Acad. Wetensch.*, **15**, *No.* 10, 16 *pp.* (1953) *In Dutch.*

Measurements of streaming-potentials were carried out on diaphragms and on models of diaphragms, consisting of two capillaries of different widths connected in series. Aqueous solutions of KCl and $AgNO_3$ ($\sigma_w \simeq 10 \times 10^{-10}$ ohm^{-1}) and methanolic solutions of K ($\sigma_w \simeq 1 \times 10^{-10}$ ohm^{-1}) were studied. Abnormal ζ-c-curves occur only in systems of large surface conductance; this confirms Overbeek and Wijga's theory. Measurements on models of diaphragms allow this theory to be tested quantitatively; the theory is confirmed by experiment. A.

ELECTRIC DISCHARGES 537.52

537.521

11088. Energy distribution function of electrons in pure helium. F. H. Reder and S. C. Brown. *Phys. Rev.*, **95**, 885–9 (*Aug.* 15, 1954).

A solution for the Boltzmann transport equation is presented, which allows one to predict high-frequency gas discharge breakdown fields in gases with constant collision frequency of the electron. Theoretical values are in good agreement with the experimental data. This is used to justify the use of the distribution function for determining the average electron energy and the various power losses of an electron in a discharge as a function of E/p. A.

537.521

11089. Microwave determination of the probability of collision of electrons in helium. L. Gould and S. C. Brown. *Phys. Rev.*, **95**, 897–903 (*Aug.* 15, 1954).

A previously reported [Abstr. 364 (1952)] microwave method for determining the collision probability for momentum transfer of slow electrons has been modified so that a variation in average electron energy from 0·012 eV to 3 eV may be obtained. Measurements of the ratio of the real part to the imaginary part of the electron conductivity are performed in the afterglow of a pulsed helium discharge in a microwave resonant cavity. The average electron energy is varied by applying a microwave electric field in the afterglow and, under appropriate assumptions, the average electron energy is determined theoretically from this field. Measurements are also obtained by varying the gas temperature from 77°K to 700°K. The value of the collision probability for momentum transfer in helium is $18 \cdot 3 \pm 2\%$ cm^2/cm^3 per mm Hg from 0 to 0·75 electron volts and increases slowly to a peak value of $19 \cdot 2 \pm 2\%$ at 2·2 eV. A.

537.521.7

11090. Space charge formation and the Townsend mechanism of spark breakdown in gases. R. W. Crowe, J. K. Bragg and V. G. Thomas. *Phys. Rev.*, **96**, 10–14 (*Oct.* 1, 1954).

The Townsend criterion for electrical breakdown in gases is based upon a singularity in the Townsend expression for the current as a function of voltage. The conventional derivation of this equation involves the assumption that space charges are absent. A more precise expression of this criterion, involving the effects of space charge, removes the singularity and describes a current that is finite at every finite point. Beyond a certain current, however, the derivative of the current with respect to voltage becomes negative, indicating that the system is incapable of withstanding a voltage larger than that at which the negative characteristic develops. In most cases, the breakdown voltage so established should not differ appreciably from that given by the ordinary Townsend equation. The second Townsend coefficient is normally determined from the curvature found, as the sparking separation is approached, in plots of the logarithm of the current *v.* electrode separation at constant electric field. The extent of this curvature can be influenced somewhat by distortion of the electric field by space charges if the initial photocurrent from the cathode is sufficiently large. A.

537.523.4

11091. Gas density and temperature in a spark discharge. G. G. DOLGOV AND S. L. MANDEL'SHTAM. *Zh. éksper. teor. Fiz.*, **24,** *No.* 6, 691–700 (1953) *In Russian.*

Describes the apparatus used, comprising the interferometer of Rozhdestvenskiĭ (1910), which enabled the gas-density distribution across the spark discharge to be investigated at different moments of time. The results obtained confirm the hydrodynamic theory developed for the formation of the spark-discharge channel by Abramson, Gegechkori, Drabkina and Mandel'shtam [*Zh. éksper. teor. Fiz.*, **17,** 862 (1947)]. The average gas density in the discharge channel is $\bar{\rho} \simeq 5 \times 10^{-6}$ g/cm^3, the corresponding concentration of particles being $N \simeq 10^{17}$ cm^{-3}. The average gas temperature in the channel is $T \simeq 40\,000$°K. F. LACHMAN

537.525.4

11092. Period of the building-up of discharge in air for non-homogeneous electric fields. I. E. BALȲGIN. *Zh. éksper. teor. Fiz.*, **24,** *No.* 5, 562–70 (1953) *In Russian.*

Describes the apparatus used and presents the results of experiments conducted in air at 30–760 mm Hg for spark gaps of 100 and 500 mm between a point and a plane surface. The features of the building-up of the discharge are shown to be determined by the polarity of the point, spark-gap length, overvoltage on the electrodes and air pressure. Neither the streamer nor Townsend theory lend themselves for explaining the building-up of discharge at low pressures. In some cases of the spark development, both the streamer and Townsend mechanism are probably merely the details of the more complex gas-discharge mechanism. [See also Abstr. 2338 (1946); 1923 (1949).] F. LACHMAN

537.523.4

11093. Elementary processes in the spark-discharge channel. S. L. MANDEL'SHTAM AND N. K. SUKHODREV. *Zh. éksper. teor. Fiz.*, **24,** *No.* 6, 701–7 (1953) *In Russian.*

In connection with experimental results described by Vaĭnshteĭn, Leontovich, Malyavkin and Mandel'shtam [Abstr. 8311 (1954)] this paper analyses the conditions of spectrum excitation and ionization of atoms in the spark-discharge channel. It is found that, while the distribution of the atoms among the excitation levels follows the Boltzmann equation, their ionization is described by the Saha equation, the electron temperature being taken as temperature in both cases. The period of equalization of the electron and gas temperatures is $\sim 10^{-7}$ sec, that of attaining equilibrium distribution for excitation is of the order of 10^{-10} sec and for ionization 10^{-7} sec. Although experiments were conducted with sparks in air, the conclusions are probably applicable to other gases, too. F. LACHMAN

537.525 : 538.6

11094. Galvomagnetic and thermomagnetic effects in a plasma. A. A. WARE. *Proc. Phys. Soc.* [*London*] *A*, **67,** 869–80 (*Oct.*, 1954).

The analysis of Davydov and of Tonks and Allis has been repeated to obtain the electrical and energy transport equations for a plasma subject to a magnetic field in which the isotropic part of the distribution is assumed Maxwellian but in which the momentum transfer due to electron self-interactions can be neglected. The validity of the various simplifying assumptions is considered. The exact coefficients have been evaluated and because of their unwieldy nature simpler approximate expressions are suggested and compared with the correct coefficients. The galvomagnetic and thermomagnetic effects are considered and it is shown that in addition to the Hall effect the Ettingshausen effect may also be important in laboratory discharges. The latter is suggested as a possible cause of the retrograde motion of an arc spot in a transverse magnetic field. A.

537.525.7

11095. Van der Waals' adsorption as a determinant of Joshi effect. N. A. RAMAIAH. *J. chem. Phys.*, **22,** 1507–13 (*Sept.*, 1954).

The significance as a determinant of Joshi effect Δi in H_2O vapour of the predischarge adsorption consisting of an instantaneous uptake of molecules due to van der Waals' forces and slow process of sorption on Langmuir sites was investigated. Joshi effect corresponding to 15–20% reversible current suppression was detected with a predischarge interval = ½ min; it was not altered by increase of this last to 5 hr or favoured by "ageing" under discharge, which indicated that the instantaneous process, viz. van der Waals' adsorption, which was quite distinct from Langmuir sorption formed during the predischarge interval and/or under discharge, was the chief seat of Δi. It was suggested that under light, surface molecules dissociated into atoms and/or radicals which possessed large electron affinity, to increase the work function of the cathode and, therefore, to give Δi. Observation of Δi even with longer wavelengths than those corresponding to dissociation energy of H_2O suggested that the adsorbed molecules possessed, prior to irradiation, certain energy $h(\nu_d - \nu)$ obtained by ionic bombardment under applied fields (ν_d is the frequency corresponding to dissociation energy of a molecule, and ν is that employed for observing Δi). A.

537.525.72

11096. Stratified high-frequency discharge in inert gases. A. A. ZAĬTSEV AND KH. A. DZHERPETOV. *Zh. éksper. teor. Fiz.*, **24,** *No.* 5, 516–28 (1953) *In Russian.*

Conditions under which the stratified structure is formed in the high-frequency discharge were studied in (mostly Ne-filled) 70 cm long discharge tubes of 1–6 cm dia., with inner or outer electrodes. It was found that, in a discharge which is symmetrical with regard to the centre, stationary strata are formed, a certain minimum current density being required for their appearance. The period of stratified structure (length of the layer) depends on gas pressure, tube radius and current intensity, changing in the same sense as the tube radius and increasing as the two other magnitudes decrease. When the symmetry of the discharge is disturbed, the strata begin to move in the direction of the positive ion drift. It is possible to control the migration rate of the movable strata continuously within wide limits, and also to bring them to a stop. A kind of movable strata was discovered, which has the nature of disturbance waves propagated from the source of density oscillations of the space discharge. F. LACHMAN

537.525.8

11097. Production of positive Joshi effect in chlorine under electrical discharge. B. B. PRASAD. *J. sci. Res. Banaras Hindu Univ.*, 3, 7–18 (1952–53).

The experimental conditions for the production of $+\Delta i$, viz. a photo-increase of the conductivity under electrical discharge were comparatively less understood and largely restricted within a narrow potential region just less than Vm, the threshold potential where the gas breaks down as a dielectric. Results are given of the investigation of $+\Delta i$ at large potentials in regard to the transition $-\Delta i$ to $+\Delta i$. With thermionic tube detectors and suitable capacitative and resistive couplings a $+\Delta i$ of 0–400% has been obtained with ordinary white light. It is found that under a given condition $\pm\Delta i$ both occur simultaneously and the origins lie in various frequency bands of the discharge current. A.

537.525.8

11098. Method of purifying the surface of glass and metal by a gas discharge. V. V. KARASEV AND G. I. IZMAĬLOVA. *Zh. tekh. Fiz.*, **24**, *No.* 5, 871–4 (1954) *In Russian.*

Glass surfaces required for the study of surface phenomena are purified by subjection to a glow discharge at 0·4–0·6 mm/Hg between two aluminium disks, 90 mm part, of which the upper one is about the same size as the object to be treated. Optimum current is 25 ± 2 mA. The purity of the surface was confirmed: (*a*) by the fact that moisture condenses on it as a continuous film; (*b*) that it has a higher coeff. of dry friction than that of glass cleaned by conventional methods; and (*c*) by the absence of any surface projections under the electron microscope (× 30 000). R. C. MURRAY

537.525.8 : 538.561

11099. Origin of r.f. oscillations in a.c. "silent" discharges. S. R. KHASTGIR AND C. M. SRIVASTAVA. *Proc. Nat. Inst. Sci. India*, 20, 290–7 (*May–June*, 1954).

An electronic theory of the origin is given. According to Loeb and Meek's streamer theory, when the applied field is adequate for Townsend's cumulative ionization, there is a conical distribution of pos. ions drifting towards the cathode. In an a.c. "silent" discharge, the negative charge formed on the intervening glass surface attracts the pos. ions of the conical column and forms a stationary array of pos. ions close to the glass surface. A gap is also set up between this stationary layer of pos. ions and the moving column of pos. ions which soon becomes highly conducting by attracting to itself electron avalanches and photo-ionized electrons. The gap is subsequently bridged up when the density of the negative charge on the glass surface attains a requisite value producing what has been called a Townsend pulse. Before this requisite density is attained, the gap exists and electronic oscillations of Barkhausen and Kurz type are set up near the glass surface opposite to the anode. These oscillations are maintained till the gap is bridged up. Accordingly electronic oscillations arise which are maintained intermittently, each train being followed by a Townsend pulse. The expression for the frequency (or wavelength) of the electronic oscillations has been shown to be of the same form as the Barkhausen–Kurz formula for electronic oscillations in a plane triode. The theory explains the general features of the oscillations and also the effects of light and heat on the frequency of the oscillations, recently observed by Khastgir, Setty and Srivastava. A

537.525.92

11100. On the dependence of the decay times o space charges by the static characteristic in intermitten discharges. D. BRINI, O. RIMONDI AND P. VERONESI *Nuovo Cimento*, **12**, 413–24 (*Sept.*, 1954).

The results of measurements on the decay times o space charges and their dependence on the static characteristic of the tube and the external circuit are reported. The results show a dependence of such times on the external circuit, but stress the existence of a true decay time of the space charges, which is no influenced by the external circuit and is dependen only on the static characteristic of the tube. An empirical method for the calculation of the decay times of space charges is given. A

537.527.

11101. Investigation of the voltage-current corona characteristic. N. WADJIH. *J. Rech. Cent. Nat. Rech Sci.*, **5**, 216–54 (*Dec.*, 1953) *In French.*

A theoretical analysis is presented of the corona discharge produced by a single pos. wire in a concen tric cylinder. Considerable discrepancies are found to exist between observed values of the corona curren as a function of applied voltage and an earlier equatio [*Ann. Phys.* [*Leipzig*] **16**, 588–612 (*March*, 1933) derived for the conduction of unipolar ions assumin a negligible modification of the field strength by spac charges. An alternative theoretical treatment i proposed taking into account the development o space charges and this is shown to give good agree ment with experimental data. The test apparatus use is described, and experimental results are given for th corona current in dry air and for pressures up t 10 kg/cm² with varying diameter of the outer cylinder R. H. GOLD

X-RAYS 537.531

537.531 : 535.33.0

11102. The resolving power of a large bent crysta spectrograph. A. E. SANDSTRÖM. *Ark. Fys.*, 8 *Paper* 10, 129–46 (1954).

Some line groups have been recorded with a larg bent crystal instrument and a Geiger counter. The X-ray tube is described as well as devices for its adjustment relative to the crystal. To study how the diffraction pattern of the crystal and other broadening effects combine with the natural line-width, a special apparatus was built for scale model experiments. The results confirm the validity of the equation $W_m^2 = W_\lambda^2 + W_c^2$, W_m, W_λ and W_c being the full widths at half maximum of the recorded line, the natural line and the diffraction pattern, respectively. By means of this equation and comparison with two-crystal measurements the resolving power of the bent crystal instrument has been estimated as regards ideal conditions as well as in practice. The widths of some *L*- and *M*-series lines are given. A.

537.531 : 535.331

11103. Notes on soft X-ray spectra, particularly of the Fe group elements. H. W. B. Skinner, T. G. Bullen and J. E. Johnston. *Phil. Mag.*, **45,** 1070–80 (*Oct.*, 1954).

Describes some old unpublished work on the *L* and *M* bands of the Fe group metals, and compares the results with new work by Cauchois (1953) and Gyorgy and Harvey (1952 and 1954). A number of differences are discussed. The results support Farineau's old curves for Cu as against Cauchois', and evidence cannot be found for the sharp *M*-emission edges found by Gyorgy and Harvey. Some comment is also given about various suggestions on the general interpretation of soft X-ray levels. A.

537.531 : 535.338

11104. Isotope shift in X-ray spectra of heavy elements. G. Igo and M. S. Wertheim. Letter in *Phys. Rev.*, **95,** 1097 (*Aug.* 15, 1954).

The expected shifts for the lines measured by Rogosa and Schwartz [Abstr. 3533 (1954)] were calculated by volume effect theory [Rosenthal and Breit, *Phys. Rev.*, **41,** 459 (1932); Breit, *Phys. Rev.*, **42,** 348 (1932)] and shown to be too small to be detected. A. R. STOKES

537.531 : 535.345

11105. Some physical measurements in the Grenz ray region. J. Vennart. *Brit. J. Radiol.*, **27,** 524–31 (*Sept.*, 1954).

This paper describes the calibration of a standard Grenz-ray equipment and shows how a film type chamber may be used for the correct measurement of output under certain specified conditions. The results of absorption measurements at 5–12 kVp in Cellophane, aluminium, air and skin are reported and an empirical formula is shown to fit the experimental results with reasonable accuracy. This formula is then used to compute equivalent absorbing thicknesses in a variety of materials. A.

537.531 : 537.542

11106. A comparison of X-ray standards. H. O. Wyckoff, G. H. Aston and E. E. Smith. *Brit. J. Radiol.*, **27,** 325–9 (*June*, 1954).

Comparison of the old N.B.S. chamber and the N.P.L. chamber with the new N.B.S. chamber has shown that the two former chambers have adequate dimensions to give correct readings below about 70 kV for moderate filtration. They are in error by the order of 2 and 3% respectively between 150 and 250 kV. The smallness of the difference in the errors explains why no significant difference was found between the chambers in the 1931 comparison. An initial discrepancy between the N.P.L. chamber and the new N.B.S. chamber at low kilovoltages was traced to a capacitance error in the N.P.L. compensating system due to strain in fixing the capacitor to the rest of the system. This error provides an explanation for the disagreement in the calibrations of Boag's chambers and to a large extent for those with Roth's chambers. Comparison of the calibrations of Victoreen chambers by the two laboratories has shown differences of less than 2%, which are nearly within the range of the variation of the values for the correction factor found by one laboratory on different occasions. The calibrations with radium γ-rays are also in satisfactory agreement. A difference of 3 or 4% between the correction factor found for radium γ-rays and that for X-rays from a 2 MV Van de Graaff generator has been shown to be associated with the irradiation of the stems of the Victoreen chambers to a differing extent. This effect and others, such as changes of electrometer sensitivity, indicate that the Victoreen dosemeter has too many minor sources of error to be satisfactory as a means of comparing primary standard chambers. A.

537.531.08

11107. A survey of surface back-scatter factors for radiations generated at 200 to 250 kV. (Half-value layers from 1·0 to 3·5 mm of copper.) J. R. Greening. *Brit. J. Radiol.*, **27,** 532–4 (*Sept.*, 1954).

Surface back-scatter values based on measurements at 16 centres are tabulated for fields up to 400 cm^2 and H.V.L.'s from 1·0 to 3·5 mm Cu. The measurements, which were made under carefully controlled conditions, agreed at an H.V.L. of 1·5 mm Cu to within ± 0·02 of the mean back-scatter factors, although seven different types of X-ray generator were used. The effects of applicator end covers on back-scatter factors are investigated. A.

CATHODE RAYS . POSITIVE RAYS 537.533/.534

537.533 : 621.384.62

11108. Theory of electron beam loading in linear accelerators. G. Saxon. *Proc. Phys. Soc.* [*London*] *B*, **67,** 705–16 (*Sept.*, 1954).

An analysis is made of the waveguide circuit of a linear accelerator of electrons employing r.f. power feedback to show how the power flowing into such an accelerator varies with the beam loading. The power relationships developed may be used in conjunction with formulae for the energy gain and beam power output of a length of accelerator waveguide to calculate the performance to be expected under feedback conditions as the beam current is varied. If a bunching section forms part of an accelerator, it will have different characteristics from the rest of the accelerator and the analysis must be modified to take this into account. This applies particularly under the variable power input conditions occurring when feedback is used. Measurements made on two linear accelerators of the variation of energy with beam current have been compared with the theoretically expected performance figures, and a reasonable agreement has been found. A.

537.533 : 621.384.622

11109. A linear electron accelerator for medical applications. P. Grivet. *Ann. Radioélect.*, **9,** 37–43 (*Jan.*, 1954) *In French.*

Describes a travelling-wave linear accelerator for a maximum electron energy of about 6 MeV. An energy spectrum, giving a spread from about 3·4 to 5 MeV, is shown. The guide was 5 m long. The X-ray output was about 60 r/min at 1 m, with 4 mm Pb filtration. J. D. CRAGGS

537.533.1

11110. An electrostatic spectrograph based on an electron microscope. B. Gauthé. *C.R. Acad. Sci.* [*Paris*] **239,** 399–402 (*Aug.* 2, 1954) *In French.*

The adaptation of an electrostatic electron microscope for velocity analysis of an electron beam is described. A cylindrical lens used in the telefocal condition with an off-axis slit is employed in a system closely following that previously described by Mollenstedt [Abstr. 5038 (1950)]. The resolution obtained is better than 1 : 20 000. A.E.I. RESEARCH LABORATORY

537.533.331

11111. Calculation of an electron slit lens for use in an electron-velocity analyser. A. Septier. *C.R. Acad. Sci.* [*Paris*] **239,** 402–4 (*Aug.* 2, 1954) *In French.*

An analysis is given of the electrostatic cylindrical einzel lens used in the telefocal condition for electron velocity analysis. The optimum operating conditions are deduced. A.E.I. RESEARCH LABORATORY

537.533.335

11112. Distortion in electron lens. M. L. De and D. K. Saha. *Indian J. Phys.*, **28,** 263–8 (*June*, 1954).

The distortion produced by an electromagnetic lens of an electron microscope has been measured in different parts of the image field. From the data obtained, the distortion coefficient of the lens has been evaluated, and compared with similar values obtained by other workers. A.

537.533.35

11113. Photoemission electron microscopy experiments. L. Huguenin. *C.R. Acad. Sci.* [*Paris*] **239,** 404–6 (*Aug.* 2, 1954) *In French.*

A brief description of a new emission electron microscope with the emission excited with ultraviolet light. A voltage of 20 kV is used, and a magnification of 120 is obtained. The instrument has been applied to the study of the effect of ion bombardment on various surfaces. A.E.I. RESEARCH LABORATORY

537.533.7

11114. Researches on electron streams. I. J. Müller. *Z. angew. Math. Phys.*, **5,** *No.* 3, 203–32 (1954) *In German.*

Matrix representations of known electron flow properties are deduced and the conditions imposed by the conservation of charge and energy are derived for small departures from the stationary state (small signal theory). Only linear phenomena are considered, i.e. electron collisions in the gas kinetic sense are neglected. Streams with one or more discrete velocities and with velocity distributions are considered. In the Maxwellian case these results are of use in the study of noise. Strong magnetic fields are used to define the electron paths and therefore only the electric field components in the direction of motion are considered. A. H. W. BECK

537.533.7

11115. On some effects of velocity distribution in electron streams. S. V. Yadavalli. *Quart. appl. Math.*, **12,** 105–16 (*July*, 1954).

Based on the Liouville theorem an integral equation is obtained for the solution of electron beam problems having a velocity spread. Assuming a rectangular velocity distribution (which is justified later) the integral equation is solved by Laplace transforms to obtain the solution of the problems of small-signal velocity modulation in a drifting electron stream, and a drifting electron stream initially possessing full shot noise in each velocity class. It is shown that one obtains from the above integral equation the same results as those given by the Llewellyn equations for the case of a single-valued velocity stream. The problem of finite but narrow velocity spread in the case of an accelerated electron stream is briefly considered. A.

537.533.7 : 621.385.833 : 621.385.1.029.6

11116. The propagation of electronic space charge waves in periodic structures. O. E. H. Rydbeck and B. Agdur. *Chalmers Tekn. Hogsk. Handl., No.* 138, 20 *pp.* (1954).

Deals with the propagation of space-charge waves in cylindrical electron beams which run through a structure or a medium of periodic character. This structure may either produce a periodic variation, with a space wavelength λ_m, of the d.c. velocity of the beam, or of its diameter. But the medium itself may also vary in a periodic manner (with the space wavelength λ_m) along the path of the beam, for example its electron and ion densities (if the medium is ionized). It is shown that exponentially increasing space-charge waves (gaining waves) can be excited in the beam when the structural wavelength $\lambda_m \simeq \lambda_p/2$, where λ_p is the effective space charge wavelength of the excited mode. The maximum gain, in db, increases linearly with the square root of the beam current density. Considerable gain is technically possible with reasonable bandwidths. These, as a matter of fact, increase linearly with the gain in db. A.

537.533.7 : 621.385.833 : 621.385.1.029.6

11117. Space-charge waves in electron streams. W. Kleen. *Entwicklungsber. Siemens u. Halske*, **17,** 89–96 (*June*, 1954) *In German.*

A qualitative introduction to the behaviour of space-charge waves and their use in resistive-wall amplifier, carcinotrons, electron-wave magnetrons, etc. A. H. W. BECK

537.533.74

11118. Experimental research on multiple scattering of electrons in nitrogen, oxygen and carbon dioxide, with the aid of the Wilson chamber. J. Allewaert. *Meded. K. Vlaamse Acad. Wetensch.*, **14,** *No.* 1, 20 *pp.* (1952) *In Dutch.*

The electron momentum varied between 2000 and 7000 gauss cm. Comparing the results with the theory of E. J. Williams (1939), there is a good agreement in the region of 4000 to 7000 gauss cm, for the case of oxygen. However, considering the scattering in nitrogen, the experiments provide higher values than those theoretically predicted, in the region of 2500 to 7000 gauss cm; there is a better agreement when the electron momentum is smaller. In the case of CO_2, the measurements have shown that the scattering is much stronger than expected from Williams's theory. A.

537.533.74

11119. Experimental research on multiple scattering of electrons in thin foils of Cu, C and Au. J. Verhaeghe and J. Allewaert. *Meded. K. Vlaamse Acad. Wetensch.*, **14**, *No.* 4, 12 *pp.* (1952) *In Dutch.*

The cloud-chamber technique was used, with electron energy of about 1 MeV. The experimental results have been compared with the theory of E. J. Williams (1939). It is found that in the case of graphite foils ($\sigma = 60 \cdot 3$ mg/cm^2) and gold foils ($\sigma = 3 \cdot 35$ mg/cm^2), the deviations can be considered to be within the limits of experimental errors. By contrast, the observed scattering by copper ($\sigma = 36 \cdot 3$ mg/cm^2) turns out to be reasonably below the theoretical predictions. This deviation can probably be explained by the fact that the mean multiple scattering angle falls outside the region in which the theory is expected to be a sufficiently good approximation. A.

537.533.74

11120. The difference in the multiple scattering of electrons and positrons. C. B. O. Mohr. Letter in *Proc. Phys. Soc.* [*London*] *A*, **67**, 730–2 (*Aug.*, 1954).

The differential scattering cross-section for a single scattering is obtained by using the second Born approximation for light elements and by applying a correction to this result for heavy elements. The difference between the r.m.s. scattering angle for multiple scattering for electrons and positrons is given as a function of r.m.s. angle, energy and $Ze^2/\hbar c$.

G. E. BROWN

537.533.74

11121. Relativistic Coulomb scattering of electrons and positrons. G. Parzen and T. Wainwright. *Phys. Rev.*, **96**, 188–9 (*Oct.* 1, 1954).

The numerical tables of Feshbach for the relativistic Coulomb scattering of electrons and positrons by a nucleus of charge Z have been fitted with an analytic function. The accuracy of the analytic function is equivalent to that of the tables. A.

537.533.75

11122. Effect of chemical combination on the characteristic energy loss of electrons. L. B. Leder and L. Marton. Letter in *Phys. Rev.*, **95**, 1345–6 (*Sept.* 1, 1954).

The characteristic energy loss of 30 keV electrons in their passage through thin solid films [Abstr. 7492 (1954)] changes with the chemical form of the solid and appears to be correlated with similar shifts observed in X-ray absorption and emission.

M. A. GRACE

537.533.8

11123. Secondary electron emission of thorium oxide. A. R. Shul'man and I. D. Yaroshetskiĭ. *Zh. tekh. Fiz.*, **24**, *No.* 5, 845–7 (1954) *In Russian.*

The secondary emission of unactivated and activated samples of thorium oxide was investigated using 30–100 μsec pulses at 5×10^{-8} A. The targets were tantalum strips coated with a layer of thorium oxide to a depth of 50–100 μ. The coefficient of secondary emission σ increases when the target is heated in vacuum for 30 minutes at $T \simeq 1600$°c. Further annealing at $T \simeq 1700$°c, and higher, decreases the value of σ. Z. F. WOJNAR

537.533.8

11124. Secondary electron yield from Al by high-energy primary electrons. G. W. Tautfest and H. R. Fechter. *Phys. Rev.*, **96**, 35 (*Oct.* 1, 1954).

The yield of secondary electrons from thin ($1 \cdot 71$ mg/cm^2) aluminium foils by high-energy primary electrons is reported. The value is $0 \cdot 0397 \pm 0 \cdot 0003$ secondary electrons per primary electron from both sides of the foil. The result is independent of the primary-electron energy in the range 111–235 MeV. A.

537.533.9

11125. Suppression of coherent radiation by electrons in a synchrotron. J. S. Nodvick and D. S. Saxon. *Phys. Rev.*, **96**, 180–4 (*Oct.* 1, 1954).

Approximate expressions are obtained for the coherent radiation loss by electrons in a synchrotron in the presence of finite parallel plate metallic shields, such as the pole faces of the magnet. The results would seem to provide a useful interpolation between the two simple limiting cases of shielding by infinite plates and no shielding at all. A.

537.534 : 621.384.612

11126. The effect of field bump in a strong focusing synchrotron. K. Huke and G. Iwata. Note in *J. Phys. Soc. Japan*, **9**, 297–8 (*March–April*, 1954).

Limits are obtained for both the mean-square amplitude and the maximum amplitude of trajectories.

P. A. STURROCK

537.534 : 621.384.612

11127. The radio-frequency system of the Birmingham proton synchrotron. L. U. Hibbard. *J. sci. Instrum.*, **31**, 363–71 (*Oct.*, 1954).

Radio-frequency equipment which is used for accelerating protons to 1000 MeV energy is described. In the Birmingham synchrotron, particles are kept on a 30 ft diameter orbit by a large electromagnet and receive impulses each revolution from the electric fields experienced on entering and leaving a "drift" tube, maintained at a radio-frequency potential of 240 V r.m.s. with respect to the surroundings. As the energy increases, the magnetic field and frequency both rise in such a way as to keep the accelerated particles within an annuler space enclosed by a vacuum box. The frequency is varied from 330 kc/s to $9 \cdot 3$ Mc/s in 1 sec by means of a servo-controlled beat-frequency oscillator, and is made to track the rising field to an accuracy of $\pm 0 \cdot 1\%$ at the beginning and $+1\%$ at the end. The accelerating electrode extends over a 102° arc of the orbit and has a capacitance of 7000 pF. Its impedance level is raised by tuning over the 30/1 frequency range with a variable inductance, consisting of a coil plunged into mercury. This reduces the peak radio-frequency demand to less than 3 kVA and greatly simplifies the power amplifier. A.

537.534

11128. Proton orbits for an electrostatically strong-focused 0·5 to 5 MeV linear accelerator: 600 MeV proton linear accelerator. R. O. Ridley. *Atomic Energy Res. Establ.* [*Harwell*] *Mem. T/M* 103, 6 + xii *pp*. (1954).

Some detailed formulae are presented and possible designs of a 0·5 to 5 MeV linear accelerator are explored. Several effects cannot easily be treated analytically and are of sufficient importance to make a numerical computation desirable. The scheme of computation for the particular design chosen is described, the results are given in detail and some critical remarks are made. A.

537.534

11129. Shunt impedance calculations for proton linear accelerators. I. W. Walkinshaw, C. S. Sabel and S. Outram. *Atomic Energy Res. Establ.* [*Harwell*] *Mem. T/M* 104, 6 + xii *pp*. (1954).

Calculations have been made for the losses in resonant cavity linear accelerators, (*a*) loaded with drift-tubes and operated in 2π-mode and (*b*) loaded with drift-tubes and operated on pill boxes in π-mode. It is shown that for constant drift-tube diameter and including transit time, the first type of loading has a higher shunt impedance for protons with velocities less than $0{\cdot}4c$ whereas the pill box structure is better above this velocity. A.

537.534

11130. Shunt impedance calculations for proton linear accelerators. II. W. Walkinshaw, C. S. Sabel and S. Outram. *Atomic Energy Res. Establ.* [*Harwell*] *Mem. T/M* 105, 1 + x *pp*. (1954).

Calculations have been made as in Pt I but for varying diameters of drift tube operated in 2π-mode and as pill boxes in π-mode at a given frequency. Including a transit-time factor, it is shown that the shunt impedance decreases for increasing drift-tube diameters and that, for a reasonable shunt impedance at a wavelength of 75 cm, the drift-tube diameter should be less than 10 cm. A.

537.534

11131. Proton dynamics in the linear accelerator. I. Grid-focussed section. N. M. King. *Atomic Energy Res. Establ.* [*Harwell*] *T/M* 107, 7 + iii *pp. figs*. (1954).

By assuming a simple form for the fields in the accelerator, equations of motion for the phase and radial oscillations of the protons are derived, susceptible to a gap-by-gap computation. The various approximations involved in the treatment are discussed. The results of the orbit computations have been interpreted so as to lead to displacement-divergence "phase diagrams" representing the types of beam capable of being focused in the accelerator, and the resulting beams at 10 MeV have been determined. The results indicate that, due to large radial excursions of non-synchronous protons, the actual range of particles trapped in phase will be more curtailed than was suggested by previous considerations. A.

537.534 : 621.384.62

11132. Determination of the axial field in a linear accelerator of the Alvarez type. W. Chahid. *C.R. Acad. Sci.* [*Paris*] **239,** 42–4 (*July* 5, 1954) *In French.*

The method of Bernard [Abstr. 6572 (1952)] is used. The calculation is improved by taking account of field singularities on the drift-tube edges (these are supposed to be of negligible thickness). The theory agrees well with experimental results. J. S. BELL

537.534.3

11133. On a new method for the measurement of the relative ion current intensities in the mass spectrometer. H. Ezoe. *J. Sci. Res. Inst.* [*Tokyo*] **47,** 65–79 (*July*, 1953).

Employing an alternating accelerating voltage, an a.c. amplifier consists of two parallel-branched amplifying circuits, and a commercial cathode ray tube as a detector, a simultaneous and equal-deflection measurement is achieved with a fairly good accuracy in rapid quantitative analyses. The accuracy is of the same order as is obtainable by a conventional single-collector mass spectrometer with a d.c. amplifier using a galvanometer as a detector, and is about 1% or less. A.

537.534.3 : 621.376.5

11134. Pulse modulation of an ion beam. W. Fishwick. *Onde élect.*, **34,** 110–18 (*Feb.*, 1954) *In French.*

A mass spectrograph can be constructed in which a pulse of ions all having the same energy pass to a distant collecting electrode. The transit time of the ions will depend upon their mass/charge ratio. The collecting electrode amplifier has an input which first integrates and then differentiates in order to improve the signal/noise ratio. A theoretical study is made of the working of the mass spectrograph in which the ions are produced by a pulse-modulated electron gun for both constant and pulsed accelerating fields. Modulation by deflector plates as a means of avoiding axial acceleration is discussed. Experimental data obtained with pulsed mass spectrographs are given. W. T. BLACKBAND (R)

537.534.72

11135. Magnetic analysis of a beam of positive ions, accelerated through a potential of 5–30 keV, after passage through a rarefied gas. N. V. Fedorenko. *Zh. tekh. Fiz.*, **24,** *No.* 5, 769–83 (1954) *In Russian.*

A monochromatic beam of He^+, N^+, Ne^+, K^+, A^+, Ca^+, I^+, Ba^+, Pb^+, Bi^+, N^{++}, A^{++}, Ba^{++}, A^{+++}, H_2^+, H_3^+ or N_2^+ ions was passed through H, He, Ne, N, A or Kr gas and analysed in an adjustable field. Processes of the type $I^+ \rightleftarrows I^{++}$ or I^{+++}, and $I_2^+ \rightarrow I^+ + I$, $I_3 \rightarrow I^+ + I_2^0$ or $I_3 \rightarrow I_2^+ + I^0$ were demonstrated. By varying the direction of the incident beam, differential and total cross-sections of many of the processes were determined. The latter are of the order of 10^{-15}–10^{-16} cm^2 and in general show a slow rise with energy. W. J. SWIATECKI

537.534.74

11136. Experiments on nucleon-nucleon scattering with 312-MeV polarized protons. O. Chamberlain, R. Donaldson, E. Segrè, R. Tripp, C. Wiegand and T. Ypsilantis. Letter in *Phys. Rev.*, **95,** 850–1 (*Aug.* 1, 1954).

Protons polarized to 73% were scattered on *D* and the asymmetric part of the cross-section $[\sigma(\phi = 0) - \sigma(\phi = 180°)]$ for *p–p* and *p–n* processes (as identified by coincidence with the recoil) were measured as function of scattering angle. See also abstract following. W. J. SWIATECKI

537.534.74

11137. Phase shifts for high-energy nucleon-nucleon scattering. B. D. FRIED. Letter in *Phys. Rev.*, **95**, 851–2 (*Aug.* 1, 1954).

The phase shifts of Thaler, Bengston and Breit [Abstr. 6883 (1954)] are shown to be in definite disagreement with the results of Chamberlain *et al.* (preceding abstract) on the scattering of 200 MeV polarized protons. P. T. MATTHEWS

537.534.74

11138. Mechanism of proton polarization in high-energy collisions. O. CHAMBERLAIN, E. SEGRÈ, R. TRIPP, C. WIEGAND AND T. YPSILANTIS. Letter in *Phys. Rev.*, **95**, 1105–6 (*Aug.* 15, 1954).

Absorption curves for 340 MeV polarized protons scattered on C at $\theta_2 = 9°$ confirm the high polarization of the elastic component. Left and right diffraction patterns for Al ($\theta_2 = 7$–$26°$) lead to an oscillating polarization curve, as expected from the operation of an **LS** coupling. W. J. SWIATECKI

537.534.74

11139. Polarization of nucleons elastically scattered from nuclei. W. HECKROTTE AND J. V. LEPORE. Letter in *Phys. Rev.*, **95**, 1109–10 (*Aug.* 15, 1954).

Comparison of 290 MeV W.K.B. calculations using a parabolic complex potential well with **LS** coupling, with polarizations of 340 MeV protons by Al at angles up to 27° (preceding abstract). W. J. SWIATECKI

537.534.74 : 530.145

Pseudoscalar interaction and proton-proton scattering. *See Abstr.* 10810–11

537.534.74 : 539.18 : 778.34

11140. Determination of the mass of particles stopping in nuclear emulsions by measurement of multiple scattering. A. ORKIN-LECOURTOIS. *C.R. Acad. Sci.* [*Paris*] **238**, 2311–13 (*June* 14, 1954) *In French.*

An experimental study of the formula for the mass of a particle in terms of the scattering (using a variable cell length), carried out on 27 protons, 23 π's and 3 τ's (mass $1010 \pm 135\, m_e$). Special stress on the statistical distribution of the measurements. W. J. SWIATECKI

537.534.75

11141. Equilibrium charge distribution of stripped 26-MeV nitrogen ions. H. L. REYNOLDS AND A. ZUCKER. Letter in *Phys. Rev.*, **95**, 1353 (*Sept.* 1, 1954).

26 MeV N^{3+} ions were passed through foils of Formvar. The relative abundances of the transmitted N^{4+}–N^{7+} ions produced by stripping were measured and it was shown that equilibrium was reached with foils thicker than 25 μg/cm^2. M. A. GRACE

537.534.75 : 778.34

11142. Addendum to V. V. Chavchanidze's paper "New method of determining the masses of charged particles by means of photographic emulsions." V. V. CHAVCHANIDZE. Letter in *Zh. éksper. teor. Fiz.*, **24**, *No.* 6, 748 (1953) *In Russian.*

See Abstr. 5531 (1953). To obtain right results in evaluating some track parameters, the track of the unknown mass should be divided into sections of length $l \simeq (m/m_p)L$, where m is the mass of the unknown particle, m_p, that of the calibration particle, and L, the length of sections into which the calibration tracks have been divided. Mass m can be approximated by any of the known methods (e.g. that of the grain density). F. LACHMAN

537.534.75 : 778.34

11143. Calculation of range/energy relations especially in photographic emulsions. M. BOGAARDT. *JENER Publ. No.* 6, 64 *pp.* (1953).

A short review is given of the development of photographic emulsions from a radiation detector in 1867 to an experimental tool for studying tracks of individual particles to-day. The methods for track analysis are briefly mentioned, and it is pointed out that, in the underlying case of low energy α-particles, range measurements provide practically the only reasonable method of track analysis. An outline is given of the research necessary to establish a range/energy relation in a theoretical way using experimentally determined parameters. A.

537.534.79 : 539.18

Possible example of the annihilation of a heavy particle. *See Abstr.* 11441

537.534.9

11144. The emission of light in the passage of alpha particles through gases. A. WARD. *Proc. Phys. Soc.* [*London*] *A*, 67, 841–6 (*Sept.*, 1954).

The emission of light from the tracks of α-particles in the gases argon, helium, nitrogen and methane has been studied using a photomultiplier. The specific emission along the track has been measured together with the total number of photons which are produced in the range 3000–6000 Å. The total number of emitted photons is found to be independent of pressure in the monatomic gases argon and helium, but varies with pressure in nitrogen and in mixtures of methane with argon or helium. The variation with pressure is explained by a simple theory of quenching by collision. The lifetime of the excited states responsible for the emission is estimated to be less than 10^{-6} sec. The recombination of the ions is shown to play no appreciable part in the production of the photons. A.

DISCHARGE TUBES . COUNTERS 537.54

537.542

11145. On the counting characteristics of bromine counters. K. SHINOHARA AND J. AKUTSU. *J. Sci. Res. Inst. Tokyo*, 47, 80–6 (*July*, 1953).

The effect of electron capture by bromine molecules on the counting characteristics of halogen counters has been investigated using counters filled with argon and bromine. The plateaus for these counters have considerable slopes and the efficiency decreases with the increase of the pressure of either argon or bromine.

These characteristics could be explained rather well by considering only the electron capture. Radial response curves obtained experimentally have also been explained. A.

537.542

11146. Visible light emission accompanying Geiger discharge. F. Yamasaki and M. Okano. *J. Sci. Res. Inst.* [*Tokyo*] **48,** 13–19 (*March,* 1954).

This was measured using photomultiplier tube as light detector. Intensity of light was measured as a function of applied high voltage for alcohol-quenched and bromine-quenched G–M counters. Measuring the time interval of flashes observed through two windows by the delayed coincidence method, the spread velocity of flashes along the counter length was determined. It was in accord with the velocity of spread of Geiger discharge along the anode wire for alcohol-quenched counters. In bromine-quenched counters it had values of the order of 10^8 cm/sec even in the counting region. A.

537.542

11147. The use of halogen-quenched Geiger–Muller counters with quenching probes. C. D. Florida and C. N. Davey. *Atomics* [*London*] **5,** 229–31, 236 (*Aug.,* 1954).

The use of an A.E.R.E., Type 1014a, quenching probe with halogen-quenched G–M counters to give a defined dead time has been investigated. The results show that two possible disadvantages arising from the addition of capacity across the counters, namely, increase in charge liberated per pulse and deterioration of the plateau, are not in general serious. D. R CHICK

537.542 : 537.533.8

11148. Secondary electron emission by photoelectric action and ion bombardment at the cathode in corona breakdown of argon. L. Colli and U. Facchini. *Phys. Rev.,* **96,** 1–4 (*Oct.* 1, 1954).

Differences between the secondary cathode mechanisms active in coaxial cylindrical argon-filled counter tubes with positive central wire at various gas pressures observed by E. J. Lauer at Berkeley and the authors at Milan, have been resolved as a result of recent work by the authors at Berkeley. It appears that at pressures ranging from 1000 to about 150 mm Hg, with spectroscopically pure argon, the dominant mechanism is a photoelectric liberation from the cathode caused by photons with some microseconds of time delay and of energy about 10 eV. These lead to a corona threshold with γ_p ranging from 1 to 5×10^{-3}, uncorrected for electron back diffusion. At pressures between 25 and 100 mm Hg an electron liberation by impact of A^+ and A_2^+ ions on the Ni cathode was confirmed to be important in the corona current, in agreement with Lauer's findings. This effect seems to be very dependent on the conditions of the surface and was found to be active only after a degassing at 900°c for hours. A.

537.542

11149. A note on the use of quenching circuits with Geiger–Müller counters. R. L. Gordon. Letter in *J. sci. Instrum.,* **31,** 306 (*Aug.,* 1954).

A brief discussion of the effects, sometimes encountered with quenching circuits, of the increase in counter wire potential due to quenching by external means. Reference is made to a method of eliminating this potential rise. J. D. CRAGGS

537.542

11150. Observations on the ionization produced by radium gamma rays in air-walled ionization chambers at low gas pressures. C. W. Wilson. *Brit. J. Radiol.,* **27,** 158–62 (*March,* 1954).

Describes experiments made at low air pressures to study the variation in ionization current with wall potential (negative and positive). Results are similar to those of Taylor [Abstr. 3555 (1951)] in that a current-voltage curve shows a definite saturation potential with the outer wall of the chamber positive, but none when it is negative. Many experiments have indicated a true residual current in the chamber at zero pressure. It is suggested that phenomena within chambers at low pressures involve more than electron transfer between electrodes, and reference is made to Greening [Abstr. 10278 (1954)]. D. V. MABBS

537.542

11151. A precision investigation of some aspects of parallel-plate free-air chamber geometry. L. A. W. Kemp and S. M. Hall. *Brit. J. Radiol.,* **27,** 219–27 (*April,* 1954).

An account is given of a series of precision experiments to investigate cut-off effects in a parallel-plate type of free-air chamber, and the relationship of these effects to the chamber geometry is analysed. The discussion is extended to enable estimates to be made of the errors associated with other parallel-plate chambers. In conclusion, it is shown that deficiencies in the geometry of the standard chamber in use at present at the National Physical Laboratory in England have led to errors approaching 3% in the realization of the röntgen at ordinary deep-therapy qualities. The corresponding error in the National Bureau of Standards chamber in the United States is estimated to lie between 1 and 2%. A.

537.542

11152. Statistics of photomultiplier scintillation counters. G. T. Wright. *J. sci. Instrum.,* **31,** 377–81 (*Oct.,* 1954).

The various causes of the distribution in magnitude of the voltage pulses from the scintillation counter are analysed. A general expression is derived for the variance of this distribution in terms of variations in the number of photons emitted by the phosphor, variations in collection efficiency for photons emitted at different points within the phosphor and photomultiplier statistics. The effects of phosphor imperfections, non-uniform response of photocathode and dynode structures, thermionic emission of electrons from the photocathode and satellite pulses are also considered. The use of the equations developed is illustrated by detailed discussion of some commonly occurring arrangements. A.

537.542 : 537.591

11153. On the efficiency of large area liquid scintillation counters for cosmic rays. G. H. Vaze. *J. sci. industr. Res.,* **13B,** 527–30 (*Aug.,* 1954).

A single 1P21 photomultiplier was used to view the scintillations produced in a large-area liquid counter by cosmic rays, and the efficiency data obtained with the instrument are presented. The difficulties and limitations of using a single photomultiplier are discussed. A.

537.542 : 578.08 : 616–073.75

11154. Scintillation detectors in medical and biological research. II. E. H. Belcher. *Atomics* [*London*] 5, 245–9, 266 (*Sept*., 1954).

For Pt I, see Abstr. 10281 (1954). Deals with directional scintillation counters and with scintillation detectors for the measurement of radiation dose: future applications are discussed. A.

537.542 : 519.2

Counters with random dead time. *See Abstr*. 10727

537.542

11155. Arrangement of delayed coincidences with a resolving period of 10^{-7} sec. A. O. Vaĭsenberg. *Zh. éksper. teor. Fiz*., **24**, *No*. 5, 545–9 (1953) *In Russian*.

An electronic circuit for delayed coincidences, suitable for measuring periods in the range from 2×10^{-7} to 10^{-5} sec, is fully described and illustrated. It is one of the variants of the arrangement described by Zhdanov and Naumov [Abstr. 3299 (1949)], involving the use of the self-extinguishing counters as detectors, which generate the short-period voltage pulses when a meson or disintegration particle passes through them. It has been found that, in counters 80 cm long and 3 cm dia., filled with A (8 cm Hg) and methylal (1 cm Hg), a lag of 0·5–1 μsec occurred once in 400, and a lag exceeding 1 μsec once in 5000 passages. F. LACHMAN

537.542

11156. An instrument for measuring energies and angular distributions of charged reaction products. C. H. Westcott, H. I. S. Allwood, J. N. Dodd, D. H. Simmons and C. J. Baker. *J. sci. Instrum*., **31**, 371–4 (*Oct*., 1954).

Equipment constructed for studying reactions induced by the external beam of the Birmingham cyclotron is described. An arrangement of proportional counters with absorbing foils, the whole rotatable in azimuth, is used for measuring angular and range distributions for the protons or other emergent charged particles. Both rotation and foil-changing are remotely controlled, completely avoiding health hazards for the operators during the experiments. The present paper describes principally the mechanical system; the counting systems are varied somewhat for different experiments, and are therefore described only in outline. A.

537.542

11157. Some cold cathode valve circuits used in the measurement of radioactivity. D. H. Peirson. *Atomic Energy Res. Establ*. [*Harwell*] *Rep. EL/R* 1204, 3 + iii *pp. figs*. (1953).

For the purpose of surveying and monitoring levels of natural radioactivity circuits employing cold cathode valves have been designed to operate from Geiger–Müller and scintillation counters. These circuits exploit the low power consumption and robustness of the cold cathode valve compared with the conventional hard valve. Considerable practical use has demonstrated the reliability of these methods. Application in other fields is indicated. Use of the cold cathode valve at the higher counting rates is restricted by deionization time. A.

537.542 : 621.385.12 : 621.374.32

11158. A scaling unit employing multi-electrode cold cathode tubes. K. Kandiah. *Atomic Energy Res. Establ*. [*Harwell*] *Rep. EL/R* 1112, 13 + xiii *pp. figs*. (1953).

For abstract, see Abstr. 6895 (1953). See also Abstr. 8375 (1954).

537.542

11159. A simple method of controlling and maintaining constant the expansion ratios of cloud chambers. G. Pfotzer. *Mitt. Max Planck-Inst. Phys. Stratosphäre No*. 2, 9 *pp*. (1954). Shorter version in *Rev. sci. Instrum*., **25**, 251–2 (*May*, 1954).

The system combines the mechanical simplicity of the constant compression-pressure system with the precision of the more complicated system with fixed stops for the travel of the piston.

537.542

11160. Description of a Wilson chamber. R. R. Roy, van de Leemput and M. Étienne. *Bull. Acad. Roy. Belgique Cl. Sci*., **40**, *No*. 6, 625–9 (1954) *In French*.

Describes a 24 cm Wilson chamber, with a detailed diagram of the firing mechanism. Photographs are given of: (*a*) an elastic positron collision, (*b*) a positron annihilation followed by a pair production and, finally, (*c*) an inelastic positron collision, giving two electrons. J. D. CRAGGS

537.542

11161. The continuous diffusion [cloud] chamber. R. R. Roy and M. L. Goes. *Bull. Acad. Roy. Belgique Cl. Sci*., **40**, *No*. 6, 630–6 (1954) *In French*.

Describes a 23·5 cm diffusion chamber and briefly discusses the conditions necessary for sharp track formation. J. D. CRAGGS

537.542 : 53

Summer school lectures on cloud chambers and bubble chambers. *See Abstr*. 10767

537.543 : 518.5 : 621.385.832

11162. The physics of cathode-ray storage tubes. C. N. W. Litting. *J. sci. Instrum*., **31**, 351–6 (*Oct*., 1954).

The mechanism of cathode-ray tube storage and the original theory developed at Manchester are first described, together with a conflicting theory proposed by other workers. Various experiments designed to obtain evidence on controversial points are described. It is shown that the original theory, though wrong in detail, may still be used to predict the results of many storage experiments. A triode theory is expounded which draws an analogy with a triode valve and gives a satisfactory explanation for the results of the various experiments. A.

IONIZATION . THERMIONICS 537.56/.58

537.561

11163. Appearance potential studies. I. Determination of excess kinetic energy. R. J. Kandel. *J. chem. Phys*., **22**, 1496–9 (*Sept*., 1954).

The metastable ion suppressor on the Consolidated

Engineering Corporation Model 21–103 mass spectrometer has been used as a retarding potential device to determine the excess kinetic energies possessed by the ions formed during appearance potential measurements. The suppressor setting at which an ion beam is extinguished is compared with the extinction setting for an ion beam with no excess energy. These settings are studied as a function of ionizing voltage, extrapolated back to the appearance potential, and converted into units of energy. N^+ from N_2 was found to have no excess kinetic energy at the appearance potential. CH_3^+ from C_2H_6, CH_3^+ from C_3H_8, CN^+ from C_2N_2 and CH_3^+ from $C_6H_5CH_3$ were all formed with excess kinetic energy. The following quantities were deduced after taking the excess energy into account: $D(CH_3 - CH_3) = 3{\cdot}87$ volts; $D(CH_3 - C_2H_5) = 3{\cdot}70$ volts; $I(CN) = 15{\cdot}13$ volts; $I(C_6H_5) = 9{\cdot}90$ volts; $D(C_6H_5 - CH_3) = 3{\cdot}80$ volts; $D(C_6H_5 - H) = 4{\cdot}64$ volts. A.

537.561

11164. Photoionization and total absorption cross section of gases. I. Ionization potentials of several molecules. Cross sections of NH_3 and NO. K. Watanabe. *J. chem. Phys.*, **22**, 1564–70 (*Sept.*, 1954).

Ionization potentials determined by examining the long wavelength limit of the ionization continuum for H_2S, CS_2, C_6H_6, toluene, *p*-xylene, C_2H_4, butadiene, and CH_3I agreed with spectroscopic values obtained by Price and co-workers. Values are reported also for NH_3, NO, acetone, methyl-ethyl-ketone, CH_3OH, and C_2H_5OH. Improved energy measurements showed that photoionization cross-sections of NO in the region 1070–1340 Å obtained earlier were about 40% too low. At 1215·6 Å the photoionization and the total cross-sections are $2{\cdot}0 \times 10^{-18}$ and $2{\cdot}4 \times 10^{-18}$ cm^2, respectively, the difference being ascribed to an absorption band. The photoionization cross-section of NH_3 was found to rise rather gradually with decreasing wavelength in the region 1220–1060 Å and to reach a value of 9×10^{-18} cm^2 at 1060 Å. A.

537.563

11165. Charge neutralization by reaction between positive and negative ions. J. L. Magee. *Disc. Faraday Soc.*, *No.* 12, 33–44 (1952).

The mechanism of reaction between positive and negative ions is examined for application to polyatomic ions of interest in radiation chemistry. It is found that polyatomic ions are expected to have larger neutralization cross-sections and a greater diversity of products than corresponding atomic cases. Metathetical processes of the type $A^+ + B^- \rightarrow C + D$ are not expected to occur. Estimates of the cross-sections for neutralization of O^+ by O^- and by O_2^- are made. A.

537.563

11166. Gaseous ions and their reactions. H. S. W. Massey. *Disc. Faraday Soc.*, *No.* 12, 24–33 (1952).

The first part is concerned with the nature of gaseous ions. Information available from experiments on the formation of clusters by alkali metal ions is discussed. Clusters are formed not only with polar molecules but also rare gas atoms. The recent work on the molecular ions of the rare gases is also described. Some special features of negative atomic and molecular ions are summarized and attention is drawn to the importance of ions existing in metastable states. The second part is concerned with the rates of reactions in which ions are involved. These are classified under five headings: reactions leading to production of positive ions, formation of negative ions, change in the nature of the ions, detachment of electrons from negative ions and recombination. The different processes which can occur in these various categories are listed and some indication of the factors which determine their rates is given. A.

537.564

11167. Inelastic heavy particle collisions involving the crossing of potential energy curves. I. Charge transfer from H atoms to Be^{2+}, Si^{2+} and Mg^{2+} ions. D. R. Bates and B. L. Moiseiwitsch. *Proc. Phys. Soc.* [*London*] *A*, **67**, 805–12 (*Sept.*, 1954).

The charge transfer processes $H + Be^{2+} \rightarrow H^+ + Be^+$, $H + Si^{2+} \rightarrow H^+ + Si^+$ and $H + Mg^{2+} \rightarrow H^+ + Mg^+$ are investigated using the Landau–Zener formula for the transition probability arising from the pseudo-crossing of the potential energy curves of the initial and final systems. These pseudo-crossings occur at internuclear distances of $5{\cdot}8_1$, $9{\cdot}6_4$ and $18{\cdot}9_2$ atomic units respectively (allowance being made for the effect of polarizability). It is found that the corresponding values of the energy separation due to the interaction between the initial and final states and $8{\cdot}6_0 \times 10^{-1}$, $1{\cdot}0_2 \times 10^{-1}$ and $2{\cdot}3_4 \times 10^{-5}$ eV. The cross-sections associated with the three processes are calculated over a wide range of impact energies. A.

537.564

11168. Probability curves near threshold for the formation of He^+, Ne^{++}, A^{++}, Kr^{++}, and Xe^{++} by electron impact. W. M. Hickam, R. E. Fox and T. Kjeldaas, Jr. *Phys. Rev.*, **96**, 63–5 (*Oct.* 1, 1954).

The formation of He^+, Ne^{++}, A^{++}, Kr^{++}, and Xe^{++} as a function of electron energy is studied with essentially monoenergetic electrons. The He^+ curve obtained in this way for an energy range of eight volts above the ionization threshold does not exhibit any detectable departure from linearity. The accuracy is such that the difference between a 1·0 and 1·1 power curve is detectable for this energy range. The ionization probability curves of the doubly charged ions is interpreted as the superposition of linear excitation curves arising from each of the $^3P_2$, $^3P_1$, $^3P_0$, $^1D_2$, and $^1S_0$ states of the ions. A.

537.565 : 551.594.13

11169. A modified McClelland method for measuring ionic mobilities. P. J. Nolan and P. J. Kenny. *J. atmos. terrest. Phys.*, **2**, *No.* 5, 266–71 (1952).

The limits of the large ion group spectrum in room air are investigated by a modification of the McClelland mobility method. An aggregation scheme based on these limits is suggested. This scheme accounts to some extent for the large ion grouping previously observed. A.

537.568

11170. Electron capture by ions passing through gases. N. C. Sil. *Indian J. Phys.*, **28**, 232–8 (*May*, 1954).

The cross-section for the capture in different excited *s*-states of an electron by an ion passing through gaseous matter has been evaluated; the method followed is an extension to that of Brinkman and Kramers. It is found that the first term of the series obtained here for the 1*s*–*ns* capture agrees with Brinkman and Kramers' approximate result. A.

537.583

11171. Spectral dependence of thermionic emission with activation from (Ba–Sr)O cathodes over 0·6–3·5 eV region. T. Hibi and K. Ishikawa. *Phys. Rev.*, **95**, 1183–4 (*Sept.* 1, 1954).

See Abstr. 2798, 8287 (1952). The spectral dependence of thermionic emission with activation from (Ba–Sr)O cathodes was observed in the region 0·6–3·5 eV by using a monochromator. At 775°K in the early stage of activation, an intense peak appeared at about 3·2 eV and, with further activation, it gradually increased. In addition several other peaks appeared in the visible and infrared regions. A remarkable temperature dependence of the 3·2 eV peak intensity was also observed during activation. Also, on cathodes which were difficult to activate, a peak at about 2·3 eV first appeared in the earliest stages of activation and then the total thermionic emission decreased with light illumination in the ultraviolet region. A.

COSMIC RAYS 537.591

537.591 : 53

Summer school lectures on cosmic rays. *See Abstr.* 10767

537.591.08

11172. Flight characteristics of expansible balloons. J. F. Darby, V. D. Hopper, J. E. Laby and A. R. W. Wilson. *Austral. J. Phys.*, **6**, 471–9 (*Dec.*, 1953).

A general study is made of the factors governing the flight of rubber balloons for cosmic-ray research, and a brief account is given of the methods that have been used to obtain long exposures at great heights. The results of incidental upper air wind observations in Victoria over a period of 18 months are included. A.

537.591.08

11173. A counter-tube apparatus for the registration of cosmic rays. A. Ehmert. *Mitt. Max Planck-Inst. Phys. Stratosphäre, No.* 2, 14 *pp.* (1954).

Describes the apparatus used by the author for observations of cosmic-ray variations [Abstr. 419 (1949), 2137 (1950), 1103–4 (1952)].

537.591.08 : 551.508.11

11174. High-altitude free balloon flying. N. C. Barford, G. Davis, A. J. Herz, R. M. Tennent and D. A. Tidman. *J. atmos. terrest. Phys.*, **5**, 219–29 (*Sept.*, 1954).

An account is given of experience gained in the high altitude flying of extensible balloons, and a theory is derived, based on the elementary gas laws, which agrees well with this. Both theory and practice show that it is very difficult to decide how much free lift to give to closed extensible balloons at launching in order to achieve level flight at a predetermined height. This difficulty may be overcome by using a valve which opens the balloon when it reaches the desired altitude, and the reliability of the balloon then becomes the chief consideration. Laboratory experiments were also carried out to provide quantitative information about the properties of various balloon fabrics. A.

537.591.1

11175. Determination of the mass of the charged cosmic-ray particles with a life period of 2 μsec. A. O. Vaĭsenberg, G. A. Marikyan and V. M. Kharitonov. *Zh. éksper. teor. Fiz.*, **24**, *No.* 5, 550–61 (1953) *In Russian.*

See Abstr. 1032 (1950), 11155 (1954). The research was carried out to provide answers to the following questions: (1) Does the air stream of cosmic rays at an altitude of 3250 m contain, besides the μ-mesons, also other unstable particles with the same life period? (2) What is the nature of the decay of particles to which a mass greater than that of the proton should be ascribed? Masses of particles decaying within 2 μsec were determined by using an apparatus which is described and illustrated; all disintegrations observed can be explained by assuming the presence of the μ- and π-mesons. Besides, decays were observed, involving the incidence of the meson-generating protons on the absorbing substance.

F. LACHMAN

537.591.1

11176. Mass measurements of slow cosmic-ray mesons. M. Inoki, T. Yasaki and Y. Matsukawa. *Phys. Rev.*, **95**, 1565–71 (*Sept.* 15, 1954).

By observing the ionization and subsequent range of individual charged slow particles, using two cloud chambers set one upon another, the mass of 36 slow particles were determined in the soft component whose ranges are less than 2·5 mm in aluminium and the mass of 12 particles in the hard component at 300 m altitude. A significant difference was observed between the results in the soft component and those in the hard component. In the latter, the 21 masses can be interpreted as representing 4 proton and 8 μ-meson masses. In the former, 11 masses are consistent with the proton mass, whereas the remaining 25, ranging over values from 54 to 649 electron masses, can hardly be interpreted as the observation of μ mesons only. The results seem to indicate the possible existence of at least two new mesons, the masses of which would be about 100 and 600 electron masses, respectively. A.

537.591.1 : 523.877

11177. On the relative abundances of primary cosmic-ray particles. P. J. D. Gething. *Mem. Soc. Roy. Sci. Liège*, **14**, *Special No.*, 524–37 (1954).

A review is made of various processes which might modify the nuclear composition of the cosmic rays between the source and the observer. Such modification would reduce the significance of the reported agreement between the abundances of elements in cosmic rays and in the stars [e.g. Bradt and Peters, Abstr. 3224 (1950); Singer, Abstr. 6437 (1953)].

537.591.15

11178. Electron density distribution near large air shower axes at sea level. R. E. Heineman. *Phys. Rev.*, **96**, 161–73 (*Oct.* 1, 1954).

A large, multiple-wire ionization chamber has been used to sample 20 separate areas of the plane of observation to obtain detailed "profiles" of the structure of large air showers within about 2 m of their axes. Interpretation of the data is based on (1) quantitative calculations of the transition effect in 0·305 radiation lengths of dural, and (2) a semi-quantitative discussion of the fluctuations in the lateral-distribution function. Lateral distribution functions for electrons and photons of various energies have been calculated for $r < 10$ m at the shower maximum and the function for electrons of all energies turns out to be essentially equal to the one given by Molière. No drastic revision of the calculated distribution function is indicated by the data, but a flatter distribution than that calculated is not ruled out. Evidence for a multiple-core structure in a small percentage of cases is presented. A.

537.591.3

11179. Anomalous absorption of cosmic rays in lead. W. L. Kennedy. Note in *Austral. J. Phys.*, **6**, 500–1 (*Dec.*, 1953).

537.591.5

11180. On the diurnal variation of cosmic rays. II. Annual change of the cosmic ray diurnal variation. Y. Sekido and S. Yoshida. *J. Geomagn. Geoelect.*, **2**, *No.* 3, 66–70 (1950).

For Pt I, see Abstr. 569 (1954). The annual changes of the solar diurnal variation at London and Tokyo in the northern hemisphere are compared with those at Canberra and Capetown in the southern hemisphere. It is shown that in addition to a systematic seasonal change in the amplitude and phase of the solar variation there may also be a sidereal daily variation of amplitude ~0·047% with a time of maximum at 17–23 h L.S.T. H. ELLIOT

537.591.5

11181. Day and night measurements of the total cosmic ray intensity at balloon altitudes. D. I. Dawton and H. Elliot. *J. atmos. terrest. Phys.*, **3**, 217–22 (*May*, 1953).

The total cosmic-ray intensity at 70 000 ft has been measured during the day and night using a single counter. A total of 18 flights has been made and no systematic difference between the day and night intensity has been found greater than the experimental error of 1·4%. This result leads to an upper limit of $0{\cdot}6 \times 10^{34}$ gauss cm^3 for the dipole moment of the sun. A.

537.591.5

11182. Time variations of the soft component of the cosmic radiation. D. I. Dawton and H. Elliot. *J. atmos. terrest. Phys.*, **3**, 295–300 (*July*, 1953).

The time variations of the soft component stopped in 10 cm Pb and the meson intensity under 10 cm Pb at sea level have been investigated simultaneously. The intensity of the soft component is primarily a function of barometric pressure but there is in addition a small negative atmospheric temperature effect. The seasonal variation of the soft component has a smaller amplitude than that for the mesons and this is shown to be consistent with the observed temperature coefficients. On the other hand, the diurnal variation for the soft component has about twice the amplitude of that for the mesons and this difference is discussed in relation to the diurnal variation in atmospheric temperature. A.

537.591.5

11183. North–south asymmetry of cosmic rays. D. S. R. Murty. *Proc. Indian Acad. Sci. A*, **40**, 96–101 (*Aug.*, 1954).

This was studied at Hyderabad; $\lambda = 7{\cdot}7°$ N and altitude 1800 ft above mean sea level. A triple coincidence counter telescope with a resolution of 7° 2′ in the zenith and 67° 22′ in the lateral plane was employed. Observations were taken at several zenith angles. The results show the southern excess of intensities at most of the zenith angles. There is a reversal of the sign of asymmetry at zenith angles 45° and 55°, which is reported for the first time at such a low latitude of 7·7° N. The values of asymmetry near the zenith and the horizon are in general agreement with the theory. A.

537.591.5

11184. Diurnal variations of the intensity of cosmic rays far underground. P. Barrett, G. Cocconi, Y. Eisenberg and K. Greisen. *Phys. Rev.*, **95**, 1571–2 (*Sept.* 15, 1954).

In the analysis of 249 762 coincidences due to cosmic rays at a depth of 1600 m.w.e. underground, no diurnal variation of the rate with respect to solar or sidereal time was found. With high confidence the amplitudes of such variations may be said to be less than 1% of the average intensity. The average energy of the primary cosmic rays responsible for the particles recorded was about 4×10^{13} eV. A.

537.591.5

11185. Atmospheric temperature effect for mesons far underground. P. Barrett, G. Cocconi, Y. Eisenberg and K. Greisen. *Phys. Rev.*, **95**, 1573–5 (*Sept.* 15, 1954).

A continuation of measurements previously reported has led to verification of the positive temperature effect for μ-mesons detected at 1574 m.w.e. underground, which are created in the atmosphere with an average energy of about 8×10^{11} eV. The new result for the temperature coefficient at this depth is $0{\cdot}33 \pm 0{\cdot}13\%$ per deg. C; and this value combined with the previous measurement yields an average of $0{\cdot}46 \pm 0{\cdot}11\%$ per deg., agreeing with the value expected if the $\pi - \mu$ decay process is responsible for all, or most, of these μ-mesons. A.

537.591.8

11186. ^{8}Li(β)^{8}Be*(2α) hammer tracks in photographic emulsions. A. R. W. Wilson. *Austral. J. Phys.*, **6**, 502–4 (*Dec.*, 1953).

537.591.8

11187. On the production of charged meson pairs by neutral particles in cosmic rays. S. B. Roy and R. Chakravarti. *Indian J. Phys.*, **28**, 167–76 (*April*, 1954).

The investigation reported by Janossy and Rochester (1941) has been repeated in Calcutta using a modified arrangement so that instead of shielding the whole threefold coincidence counter telescope with anti-counters, only the topmost coincidence counter has been shielded almost completely with anticounters. It has been observed that the number of anti-coincidences increases slightly even when a lead absorber placed between the two upper coincidence counters is moved from its position just above the lower counter to one just below the upper counter as observed by Rusk and Rosenbaum (1949), but the number increases further when this absorber is shifted from the latter position to one just above the topmost coincidence counter. This increase is again found to be the same as that observed with the diminution of the thickness of a lead absorber placed above the anti-counters from 21 cm to 2·5 cm. This increase is found to be statistically significant and about 0·4% of the total number of charged mesons recorded with the same arrangement. It is pointed out that the low value, 0·035%, reported by Janossy and Rochester is due to the failure of the arrangement to record events in which the neutral particles produced at least two charged mesons moving in widely different directions. A.

537.591.8

11188. A *V*-event associated with a star from which a *K*-meson is emitted. A. Debenedetti, C. M. Garelli, L. Tallone and M. Vigone. *Nuovo Cimento*, **12,** 369–73 (*Sept.*, 1954).

From a star observed in a stack of stripped emulsions, a *K*-meson and a neutral particle decaying in flight are emitted. The *V*-event can be interpreted either as a Λ^0 decay ($Q = 36^{+67}_{-16}$ MeV) or as a θ^0-decay ($Q = 216^{+150}_{-55}$ MeV). A.

537.591.8

11189. An analysis of three *K*-mesons ejected from stars. A. Debenedetti, C. M. Garelli, L. Tallone and M. Vigone. *Nuovo Cimento*, **12,** 374–9 (*Sept.*, 1954).

In a stack of stripped emulsions three cases of *K*-meson decays have been found. K_2 and K_3 have a mass of 915 ± 130 m_e; the secondaries cannot be identified. The mass of K_1-meson is 1020 ± 270 m_e (scattering-range) and 1165 ± 130 m_e (ionization-range); its secondary is a light meson with $p\beta = 104 \pm 24$ MeV/c. A.

537.591.8

11190. A cloud chamber study of the interactions of fast μ-mesons. V. Appapillai, A. W. Mailvaganam and A. W. Wolfendale. *Phil. Mag.*, **45,** 1059–69 (*Oct.*, 1954).

A cloud chamber operating in a magnetic field has been used to investigate the production of penetrating secondaries by μ-mesons at sea level. No definite events in which single penetrating secondaries are produced (APP) have been observed. Some possible explanations for the high cross-sections for production of APP found by earlier workers are discussed. Events in the cloud chamber attributed to the nuclear interaction of μ-mesons can be explained in terms of the virtual photon interaction postulated by George and Evans (1950). A.

MAGNETISM 538

538.08 : 621.385.833 : 621.317.42

11191. The use of an electron beam for the accurate measurement of alternating magnetic field strengths. S. E. Barden and K. Phillips. *Proc. Instn Elect. Engrs II*, **101,** 441–9 (*Aug.*, 1954).

A special electron-optical system for producing a low-energy beam, as far as possible only in the absence of a magnetic field, is described. Its use for measuring both the strength of d.c. magnetic fields relative to a static reference field, and the relative strengths of time-dependent magnetic fields, with the aid of the voltage pulse which it produces at field zero, is described. The various factors affecting the amplitude and width of such pulses are discussed, and quasi-static measurements are given in support of the conclusions derived from a simple theoretical analysis of such factors. The operation of such an instrument in time-dependent magnetic fields, such as in the betatron and electron-synchrotron, is briefly discussed. A.

538.082.103

11192. An automatically recording magnetic balance. T. Hirone, S. Maeda and N. Tsuya. *Sci. Rep. Res. Insts Tôhoku Univ. A*, **6,** 67–76 (*Feb.*, 1954).

A newly designed magnetic balance for plotting automatically the magnetization-temperature curves of magnetic substances of the ferromagnetic and other types is introduced. The essential part of this instrument consists in the automatic compensation of the unbalance due to a force acting on the sample. The change of susceptibility due to the rise or fall of temperature of the specimen can be obtained from the chart on which the current for the compensation is recorded. The new apparatus is useful in magnetic analysis of various kinds of magnetic substances. A

538.082.7 : 621.317.42

11193. A new electrodynamic method of measuring magnetic fields. S. K. Dutta Roy. *Indian J. Phys.*, **28,** 183–90 (*April*, 1954).

The method is based upon the measurement of the maximum couple exerted upon a small current-bearing coil suitably suspended with a fine torsion fibre in the magnetic field. The method is very simple, quick and with reasonable precautions gives an absolute field accuracy of the same order as standard ballistic or electrodynamic methods. Field values obtained are compared with those from search coil and crystal methods. A.

538.221

11194. Magnetization of ferromagnetics in the neighbourhood of the Curie point. K. P. Belov, A. N. Goryaga and N. I. Mikhal'chuk. *Zh. éksper. teor. Fiz.*, **24,** *No.* 6, 708–13 (1953) *In Russian.*

Presents graphed results of measurements of the relationship between temperature and the susceptibility of the para-process (magnetization proper) for Ni and some of its alloys with Fe and Cu near the Curie point. These results agree well with thermodynamic relationships developed by Vonsovskiĭ [*Izv. Akad. Nauk SSSR, Ser. fiz.*, **11,** 485 (1947)] and Ginzburg [*Zh. éksper. teor. Fiz.*, **17,** 833 (1947)].

F. LACHMAN

538.221

11195. Resonance absorption in ferrites. T. Okamura. *Sci. Rep. Res. Insts Tôhoku Univ. A*, **6,** 89–108 (*Feb.*, 1954).

The frequency shift and temperature dependence of *g*-values and of half linewidth found in the resonance absorption experiment in various ferrites were studied in the frequency range from 9450 to 47 000 Mc/s at room and at liquid nitrogen temperature. The real spectroscopic splitting factors g which are independent of frequency and temperature for nickel, manganese ferrites, nickel–zinc, manganese–zinc binary ferrites and other various ferrites were determined by using the corrected Kittel's resonance formula, including a new internal field in the materials found experimentally. A semi-empirical formula for the internal field was proposed and its nature was discussed on all simple ferrites and their binary ferrites, from various aspects, experimentally; moreover, anomalous g-values of the cobalt–zinc ferrite were explained on this ground. It was also found that the half linewidths of the nickel–zinc and manganese–zinc binary ferrites increased at high zinc ferrite contents. A.

538.221

11196. The effect of the anisotropy and the relaxation phenomena on the shift of ferromagnetic resonance in polycrystalline ferrites. M. DATE. *Sci. Res. Rep. Insts Tôhoku Univ. A*, **6**, 109–13 (*Feb.*, 1954).

The frequency-dependence of the g-values found on the resonance absorption experiments in ferrites was discussed theoretically with various aspects. It was considered whether considerable resonance shifts were caused by anisotropy and various relaxation processes or not. These considerations could not be interpreted for the experimental results obtained, and there is nothing yet to be considered as the cause of this phenomenon. A.

538.221

11197. Theory of antiferromagnetic resonance in $CuCl_2 . 2H_2O$. T. NAGAMIYA. *Progr. theor. Phys.*, **11**, 309–27 (*March*, 1954).

After a short review of Nagamiya–Yosida's theory of antiferromagnetic resonance, it is shown that this theory is equivalent to Gorter–Ubbink's at absolute zero, so far as the external field H employed in the former is replaced by H' defined by $2H'_x = g_a H_x$, etc., and the parallel and perpendicular susceptibilities are related with observed susceptibilities in a suitable way, where g_a is the value of the g-tensor in the direction of the crystalline a-axis, etc. It is then shown that the small anisotropy of the Weiss molecular field can be taken into account by introducing an anisotropy energy of orthorhombic symmetry and that in this way the anisotropic Weiss field can be replaced by an isotropic one. By using this anisotropy energy, the hyperbola in the ac-plane that defines the critical field strength is derived in a simple way for an arbitrary temperature, without making use of Weiss approximation. Yosida's theory of resonance is reviewed, and supplemented with a few more resonance formulae. It is shown that in a certain range of temperature resonance takes place at the critical field strength. There is a case such that the resonance absorption curve is semi-infinitely broad, being cut off for the field strengths inferior to the critical field strength, and this occurs at one end of that temperature range. This is in accord with Ubbink's experiment. It is shown that all the observed resonance peak positions obtained by varying the temperature and the direction of the applied field are quantitatively well explained, if one determines the three parameters entering the theory (two anisotropy constants, the ratio between them being independent of temperature, and the ratio between the parallel and perpendicular susceptibilities) from a part of the resonance data and the measurements of the susceptibilities. The change of width of resonance curve with the change of direction of the applied field, and also the polarization effect, are discussed. Further predictions from the theory are given. A.

538.221

11198. On the magnetic property of iron oxides. H. KOJIMA. *Sci. Rep. Res. Insts Tôhoku Univ. A*, **6**, 178–85 (*April*, 1954).

Pure α-Fe_2O_3 powder prepared by oxidation of $Fe(CO)_5$, was reduced to Fe_3O_4 by a hydrogen stream containing water vapour. The magnetic properties were measured at each state of reduction and the reduced grade was checked by chemical and X-ray analysis. Fe_3O_4 thus prepared was oxidized again and it was proved that the changes of the magnetic properties during oxidation and reduction coincide with one another. A.

538.221

11199. On the magnetic anisotropy energy of FeF_2. K. NIIRA AND T. OGUCHI. *Progr. theor. Phys.*, **11**, 425–36 (*April–May*, 1954).

The magnetic anisotropy energy of FeF_2 deduced from the measurement of Stout and Matarrese [Abstr. 8546 (1953)] on the magnetic susceptibility of the single crystal has a large value of $5 \cdot 3(M/M_0)^2$ cm^{-1} per Fe ion, where M, (M_0) is the magnetization (the one at 0°K), and this cannot be interpreted in terms of the magnetic dipole-dipole interaction between Fe ions in the crystal. The origin of the anisotropy energy can be explained by the spin-orbit interaction in the Fe^{++} ion. The authors have calculated the second order perturbation energy due to this interaction, taking account of the crystalline Stark effect of the ground state of the Fe^{++} ion. The crystalline field can be determined by the anisotropy of the g-factor deduced from the experiment of Stout and Matarrese. The calculated anisotropy energy per ion due to the spin-orbit interaction is $7 \cdot 6\ (M/M_0)^2$ cm^{-1}, in good agreement with the observed value. A.

538.222

11200. Periods of paramagnetic lattice relaxation for the hydrated salts of rare-earth elements. S. A. AL'TSHULER. *Zh. éksper. teor. Fiz.*, **24**, *No.* 6, 681–90 (1953) *In Russian.*

It is calculated that the periods involved are of the order of 10^{-10}–10^{-12} sec at room temperature, which agrees with experimental results. These periods are, in general, much shorter than those for the salts of the elements of the iron group. Several conclusions are drawn from the result that, at room temperature, the period of lattice relaxation is shorter than that of spin relaxation. F. LACHMAN

538.222

11201. Magnetic properties and occupation of energy bands in the alloy systems aluminium–manganese and silver–lead. E. VOGT. *Appl. sci. Res. B*, **4**, *No.* 1–2, 34–42 (1954) *In German.*

It follows from susceptibility measurements (due to R. Lingelbach and H. Friedewold) that in the phase $MnAl_6$ the Mn atoms have closed *d* shells while in the phase $MnAl_4$ they have some vacancies in the *d* shells [see also Abstr. 7561 (1954)]. The susceptibility of the Pb–Ag alloys is independent of Pb concentration up to 2% (atomic). E. P. WOHLFARTH

538.222

11202. The magnetic properties of aqueous solutions of cupric perchlorate. P. Berthier, C. Courty and J. Gauthier. *C.R. Acad. Sci.* [*Paris*] **239,** 241–3 (*July* 19, 1954) *In French.*

A continuation of previous susceptibility measurements on copper salts [Abstr. 8324 (1952)]. The effective magneton number of the Cu^{++} ion is 2·007; the curve giving the susceptibility as a function of the molality (0·009 to 5·234) is concave towards the molality axis. E. P. WOHLFARTH

538.222

11203. Spin coupling in copper cobalticyanide: resonance and susceptibility at very low temperatures. N. Perakis, J. Wucher and H. M. Gijsman. *C.R. Acad. Sci.* [*Paris*] **239,** 243–5 (*July* 19, 1954) *In French.*

An extension of previous work on the substance $Cu_6[Co(CN)_6]_4$ [Abstr. 8424 (1954)] to temperatures between 1° and 20°K. The susceptibility obeys the Curie–Weiss law over this temperature range ($\theta = -1\cdot 5$°K, $C_A = 0\cdot 322$); a weak field dependence (7×10^3 to 19×10^3 oersted) was observed between 1·4° and 4·2°K. Resonance measurements at a wavelength 3·2 cm over the temperature range 12° to 290°K gave $g = 2\cdot 17$, half-width 60 oersted. The results are compared with those for the nickel complex. E. P. WOHLFARTH

538.222

11204. Paramagnetic resonance absorption in graphite. G. R. Hennig, B. Smaller and E. L. Yasaitis. Letter in *Phys. Rev.*, **95,** 1088–9 (*Aug.* 15, 1954).

The results show graphite to have 10^{-4} spin centres per C atom at 300°K falling as $\exp[-E/(kt)]$ with $E = 0\cdot 4$ eV. Electrolytic oxidation to the lamellar compound $C^{m+}(HSO_4^- . 2H_2SO_4)_m$ alters the pattern at causes a minimum in line width of 45 milligauss at $m = 0\cdot 02$ and a zero temperature coefficient of line width at $m = 0\cdot 04$. The Br_2 and UCl_4 lamellar graphite compounds are not similar and the effect is probably associated with positive holes trapped at acceptor states, i.e. bisulphate radicals. Anomalies at 210°K may be associated with the onset of rotation. D. H. WHIFFEN

538.222

11205. The temperature variation of susceptibility of tantalum. F. E. Hoare, J. S. Kouvelites, J. C. Matthews and J. Preston. Note in *Proc. Phys. Soc.* [*London*] *B*, **67,** 728–30 (*Sept.*, 1954).

The results of measurements between 20 and 293°K are given. A quadratic form has been fitted to the results which are considered in relation to those obtained at high temperatures by Kriessman. F. E. HOARE

538.222

11206. Strong field induced paramagnetic anomaly in $NiSiF_6 . 6H_2O$. W. E. Henry. *Phys. Rev.*, **95,** 1449–50 (*Sept.* 15, 1954).

A non-Brillouin dependence of the magnetic moment (M) of nickel fluosilicate hexahydrate has been shown from experimental magnetization studies in the temperature (T) range 1·3–4·2°K and in magnetic fields (H) up to 58 000 gauss. A branching of magnetic moment isotherms, when M is plotted against H/T, not only indicates non-Brillouin dependence but also eliminates the possibility of using simple exchange interaction to explain the results. The characteristic pattern of magnetic moment dependence on H/T can be reproduced by the use of energy levels quadratic in the magnetic field, where the coefficient of the quadratic term is about $0\cdot 7\times 10^{-26}$ erg gauss^{-2}. A.

538.222

11207. Paramagnetic resonance in uranium salts. S. N. Ghosh, W. Gordy and D. G. Hill. *Phys. Rev.*, **96,** 36–8 (*Oct.* 1, 1954).

Paramagnetic resonance has been observed in U^{+3} and U^{+4} ions in powdered samples of UF_3 and UF_4, respectively. The resonance curve in UF_3 was found to be asymmetric, with two unresolved peaks yielding $g_\perp \simeq 2\cdot 1$ and $g_{||} \simeq 2\cdot 8$. The resonance is broad and weak; the over-all half-width is about 5 kilogauss at room temperature. The curve obtained for UF_4 is symmetric and yields $g = 2\cdot 5_5$. Its half-width is about 3·5 kilogauss at room temperature. Although the resonance in UF_3 appeared somewhat stronger at liquid air than at room temperature, that in UF_4 could be detected only at room and at elevated temperatures. The results favour the interpretation that the two unpaired electrons in U^{+4} are 6*d* electrons, that the crystalline field in UF_4 is essentially cubic, and that either the lowest component of the Stark multiplet is a non-magnetic singlet or that the electrons have a high degree of antiferromagnetic alignment. The results on UF_3 show that the crystalline field has an axially symmetric component. A.

538.222

11208. Paramagnetic resonance in chromous sulfate pentahydrates. K. Ono, S. Koide, H. Sekiyama and H. Abe. *Phys. Rev.*, **96,** 38–9 (*Oct.* 1, 1954).

Paramagnetic resonance absorption in single crystals of chromous sulphate pentahydrate has been observed at room temperature and at wavelengths of 11 mm, 6·5 mm and 5·4 mm. The result shows that this crystal has a structure similar to that of copper sulphate pentahydrate. The observed data have been analysed by the so-called spin Hamiltonian, and the parameters determined have been found to be quite consistent with the values of the spin-orbit coupling constant and the spin-spin interaction constant obtained from spectroscopic data. A.

538.222 : 536.48

11209. Magnetic properties of metals at low temperatures. II. Dependence of magnetic susceptibility of zinc single crystals on field strength at temperatures between 20·4°K and 300°K. B. I. Verkin and I. F. Mikhaĭlov. *Zh. éksper. teor. Fiz.*, **24,** *No.* 3, 342–6 (1953) *In Russian.*

For Pt I, see Abstr. 9601 (1951). The torsion method was used and results similar to those of McClure and Marcus [Abstr. 1956 (1952)] were obtained. The maximum field used was about 15 000 G. D. SHOENBERG

538.222

11210. Electron spin resonance in beryllium. G. FEHER AND A. F. KIP. Letter in *Phys. Rev.*, **95,** 1343–4 (*Sept.* 1, 1954).

Measurements of electron resonance at 300 and at 9000 Mc/s for Be metal embedded in wax give $g = 2{\cdot}0032 \pm 0{\cdot}0001$. The spin relaxation time $T_2 = 2{\cdot}0\times10^{-8}$ sec and is independent of temperature. The shape of the resonance is in agreement with the theory for conduction electrons. D. H. WHIFFEN

538.222

11211. Measurement of the spin paramagnetism of conduction electrons. R. T. SCHUMACHER, T. R. CARVER AND C. P. SLICHTER. Letter in *Phys. Rev.*, **95,** 1089–90 (*Aug.* 15, 1954).

The intensity of the electron paramagnetic resonance in Li metal at 6 gauss. is determined absolutely by comparison with the nuclear resonance at 10000 gauss. using the same frequency, 17 Mc/s, and the same circuit and volume parameters. The spin susceptibility is $2{\cdot}0 \pm 0{\cdot}3\times10^{-6}$ c.g.s. and is to be compared with the calculated value of Pines, $1{\cdot}87\times10^{-6}$ (abstract following). D. H. WHIFFEN

538.222

11212. Paramagnetic susceptibility of conduction electrons [in alkali metals]. D. PINES. Letter in *Phys. Rev.*, **95,** 1090–1 (*Aug.* 15, 1954).

Gives the results of a calculation including contributions due to long- and short-range electron correlations treated by the collective description due to Bohm and the author. The calculated values of χ_p for Li and Na are $1{\cdot}87$ and $0{\cdot}85\times10^{-6}$ respectively, the value for Li agreeing well with the experimental value ($2{\cdot}0 \pm 0{\cdot}3\times10^{-6}$) obtained by Schumacher *et al.* (preceding abstract). Comparison is made with the Pauli free electron values (lower) and Sampson and Seitz's values for Li and Na (higher). Some discussion is also given of diamagnetic susceptibilities [see also Abstr. 8408 (1954)]. E. P. WOHLFARTH

538.222 : 541.5

11213. Multiplicity of paramagnetic resonance lines in certain irradiated organic substances. J. UEBERSFELD. *C.R. Acad. Sci.* [*Paris*] **239,** 240–1 (*July* 19, 1954) *In French.*

Gives an interpretation of the details of the spectrum previously observed with some aminoacids and high polymers irradiated with γ-rays [Abstr. 7569 (1954)]. E. P. WOHLFARTH

538.222 : 548.7

11214. Accurate determination of the magnetic anisotropies of the hydrated salts of some elements of the iron group. S. DATTA. *Indian J. Phys.*, **28,** 239–49 (*May*, 1954).

Van Vleck's recent theory of magnetic anisotropy of paramagnetic crystals indicate the importance of the effects of long-range crystalline electric fields which were previously assumed to be small in comparison with short-range ones. Experimental verification of this theory necessitates very accurate determination of the magnetic anisotropy of such crystals. This has been undertaken in the present work in which attempts have been made to improve the existing methods in order to eliminate or minimize errors that arise in its measurement, especially in the control and measurement of the magnetic field. The results obtained on a large number of crystals show considerable differences from those obtained by the previous workers. The use of single crystals as secondary standards in the measurement of magnetic fields has been discussed. A.

538.24 : 536.48

11215. Temperature and field dependence of the de Haas–van Alphen effect. F. J. DONAHOE AND F. C. NIX. *Phys. Rev.*, **95,** 1395–402 (*Sept.* 15, 1954).

The functional dependence of the observed de Haas–van Alphen effect in zinc has been compared with the predictions of the free electron theory. The dependence of the period on the magnetic field, and of the amplitude on the temperature appear to be correctly given. However, the predicted dependence of the amplitude on the magnetic field is in disagreement with the experimental results. An empirical formula for the amplitude dependence is given which differs from the free electron formula in that it contains an additional factor of $1/H$. This formula is in good agreement with the experimental results. A.

538.24 : 536.48

11216. De Haas–van Alphen effect in tin and tin–antimony alloys. G. T. CROFT, W. F. LOVE AND F. C. NIX. *Phys. Rev.*, **95,** 1403–8 (*Sept.* 15, 1954).

The de Haas–van Alphen effect has been studied in a series of dilute alloys of tin with antimony at field strengths below 10 000 gauss. Over the range of compositions studied (0–0·23 at. % Sb) there was no observable change in the parameters characterizing the de Haas–van Alphen effect other than the collision broadening parameter X, which increased uniformly with concentration of antimony. The temperature dependence of the amplitude of the susceptibility oscillations agrees with the theoretical predictions, but there is evidence that the field dependence does not. An angular dependence of X was observed and interpreted in terms of the lattice geometry. The room temperature magnetic anisotropy was also measured and found to increase by approximately 25% for an antimony concentration of 0·23 at. %. A.

538.24 : 536.48

11217. Temperature-dependent de Haas–van Alphen parameters in zinc. T. G. BERLINCOURT AND M. C. STEELE. *Phys. Rev.*, **95,** 1421–8 (*Sept.* 15, 1954).

The magnetic susceptibility of a single crystal of zinc has been investigated from 4·2°K to 300°K in fields up to 25 kilogauss. Traces of the de Haas–van Alphen effect persisted at temperatures as high as 200°K. The period of the characteristic susceptibility oscillations increased with increasing temperature, rising from $6{\cdot}4\times10^{-5}$ gauss^{-1} at 4·2°K to $12{\cdot}5\times10^{-5}$ gauss^{-1} at 61·2°K. If present interpretations of the de Haas–van Alphen parameters are valid, temperature dependent effective masses, or chemical potential, or both are implied for the pertinent electrons. A rough calculation indicates that temperature dependences of the right order of magnitude might arise from alteration of the overlap of Brillouin zone boundaries by the Fermi surface as a result of anisotropic thermal expansion of the lattice. In addition to the main oscillations, terms exhibiting periods of approximately 2×10^{-7} gauss^{-1} were observed at 4·2°K but were not investigated in detail. A.

538.24 : 538.639

Correlation between magneto-resistance variations and the de Haas–van Alphen effect. *See Abstr.* 11250

538.247

11218. Demagnetizing factors of bars of high permeability. M. A. Rozenblat. *Zh. tekh. Fiz.*, **24**, *No.* 4, 637–61 (1954) *In Russian.*

A very comprehensive report on experimental investigations of the demagnetizing factor of solid and composite bars of rectangular cross-section as well as full and hollow cylinders of high-permeability materials, mainly molybdenum Permalloy. The report on the investigations is prefaced by an exhaustive and critical review of all the previous work in this field and by a discussion of the theoretical and experimental implications of the problem of determining true demagnetization factors considering not only geometrical configuration but also properties of the material. The theory is mainly an extension of Arkadiev's work which had been applied to the new materials so far only in a very limited range not covering to-day's practical requirements. The author's analysis of the experimental data available reveals numerous incompatibilities of results of various authors and shortcomings in experimental methods and also in the evaluation of otherwise trustworthy results. The author's own experimental set-up was comparatively simple and, rather surprisingly, did not consider elaborate types of permeameters developed elsewhere particularly for modern magnetic materials. The estimation of all possible experimental errors, reproduced in full, was carried out with the greatest care. The results so evaluated agree with the demagnetization factors calculated on Arkadiev's theory within fractional per cents for cylindrical bars (which actually were wires in the case of large ratios l/d) and within 1–2% in the case of bars of rectangular cross-section. Within the range $l/d = 10$–50 the agreement with the most reliable of the previous measurements, i.e. those of Burdin, Würschmidt, Thompson and Moss, is also very satisfactory. A semi-empirical formula for magnetometric and ballistic demagnetizing factors for practical calculations is derived. B. F. KRAUS

ELECTROMAGNETISM . ELECTRODYNAMICS 538.3/.5

538.3

11219. The direct integration of Maxwell's equations. Concerning the vectorial principle of Huyghens. A. Da Silveira. *Rev. Fac. Ciênc. Univ. Lisboa B*, **1**, 185–201 (1951) *In French.*

The author establishes a symmetrical identity valid for two fields of regular vectors **X** and **Z**, in a region v bounded by a closed surface S, where the divergences and rotationals figure explicitly. This identity permits a direct integration of Maxwell's equations: (1°) from the point of view of the instantaneous potentials by putting $\mathbf{X} = \mathbf{E}$ (or **H**) and $\mathbf{Z} = \text{grad}\ (1/r)$ or $\mathbf{Z} = \text{rot}\ (\mathbf{a}/r)$, **a** being arbitrary; (2°) from the point of view of the retarded potentials, putting $\mathbf{X} = \mathbf{E}$ (or **H**) and $\mathbf{Z} = \text{grad}\ (e^{-ikr}/r)$ or $\mathbf{Z} = \text{rot}\ (\mathbf{a}e^{-ikr}/r)$. In this last case, if the sources of the fields **E** and **H** are situated outside v, the identity gives directly, for the electromagnetic waves, the Larmor–Tedone formulae, which provide an analytical formulation of Huyghens' principle. The author makes a critical analysis of some formulae proposed to express Huyghens' principle and shows how the known formulae of Kottler may be obtained. A.

538.3

11220. Theory of strong electromagnetic waves in massive iron. W. MacLean. *J. appl. Phys.*, **25**, 1267–70 (*Oct.*, 1954).

A rigorous solution of Maxwell's equations is carried through for the case of a rectangular magnetization curve. Formulae for the depth of penetration and the wave impedance are derived yielding a theoretical power input formula which relates to the popular quasi-theoretical formula of Rosenberg by just the factor $4/\pi$. A.

538.3 : 523.1

11221. The motion of magnetic fields. J. W. Dungey. *Monthly Not. Roy. Astron. Soc.*, **113**, *No.* 6, 679–82 (1953).

The temporal change of a magnetic field cannot be described as a motion, if it involves interlinking of the lines of force. It is shown that the idea of motion can be retained, if the lines of force are regarded as being "disconnected" on a suitable surface. A process is described by which magnetic flux can be generated other than at a neutral line. A.

538.311 : 53.081.1 : 621.3.013

11222. On the rationalization of the magnetic field. E. Brylinski. *Rev. gén. Elect.*, **63**, 334–5 (*June*, 1954) *In French.*

In contradiction to the statements of a previous article [Abstr. 3965 (1954)] it is shown that the sole correct relation of equivalence between the ampere per metre and the oersted is that which gives the ampere per metre a value of 1 millioersted. Certain inexactitudes in the previous article are corrected. S. C. DUNN (R)

ELECTROMAGNETIC WAVES AND OSCILLATORS 538.56

538.5 : 621.3.011

11223. Teaching of electric circuits and dual electric circuits. E. Ikenberry and W. A. Rutledge. *Amer. J. Phys.*, **22**, 437–42 (*Oct.*, 1954).

Electric network elements are defined. Methods for analysing electric networks, both on the loop basis and on the node basis, are stated and illustrated by simple examples. The conventional method of constructing dual circuits, by drawing lines connecting loop centres, via the elements, is dualized, resulting in a construction in which loops, passing through the elements, are drawn around nodes. "Nominal voltage sources" are introduced to represent the voltages induced by mutual induction, making it possible to extend the reciprocal property of duality to all planar circuits. A.

538.561 : 537.525.8

Origin of r.f. oscillations in a.c. "silent" discharges. *See Abstr.* 11099

538.565 : 621.372.413 : 621.317.324

11224. The measurement of electromagnetic field in resonant cavities by introduction of small metallic rings. A. Gilardini. Letter in *J. appl. Phys.*, **25,** 1064–5 (*Aug.*, 1954).

Using Slater's theorem the field in a cavity can be estimated by noting the frequency perturbation when a small metal object is inserted. In this investigation, a small toroid is used and agreement between theory and experiment is found to within a few per cent. G. D. Sims

538.566

11225. The diffraction of waves by an irregular refracting medium. E. N. Bramley. *Proc. Roy. Soc. A*, **225,** 515–18 (*Sept.* 22, 1954).

A method is described of calculating the diffraction effects produced by a thick stratum of an irregular refracting medium. It consists of evaluating the statistics of the phase irregularities in the wave-front after traversing the medium, and treating these irregularities as having been produced by a thin phase-changing screen. For a particular statistical model of the irregularities in the medium the result is shown to be identical with that obtained by Fejer using a different method. A.

538.566 : 523.165

Galactic radiation at radio frequencies. The sea interferometer. *See Abstr.* 10741

538.566 : 535.55

On linearly polarized electromagnetic waves of arbitrary form. *See Abstr.* 10988

538.566

11226. Production of surface waves propagated along a single cylindrical conductor, M. D. Karasev and V. A. Apanasenko. *Zh. tekh. Fiz.*, **24,** *No.* 4, 662–6 (1954) *In Russian.*

The production of a so-called surface wave propagated along the conductor if the phase velocity on the latter is smaller than the velocity of light was predicted by Sommerfeld in 1899. Vladimirskii indicated [*Izv. Akad. Nauk SSSR, Ser. Fiz.*, **8,** *No.* 3, 139–49 (1944)] theoretically the conditions of the design of an emitter of such a "cable" wave, but this is the first report on successful experiments on the production of such waves. It was confirmed that, in contradistinction to the case of coaxial cables, the waves are propagated along the conductor without being radiated, so that the only losses occurring are those inside the conductor. The attenuation is therefore small and remained below 3 db for the 10^4 Mc/s wave produced along the conductor of 285 cm length. Half the energy of the wave is concentrated in a cylindrical coaxial space, of radius 3 cm, around the conductor. B. F. Kraus

538.566

11227. On the time constant of a cylindrical electric guide. P. Poincelot. *C.R. Acad. Sci.* [*Paris*] **238,** 2394–5 (*June* 21, 1954) *In French.*

An application of the results of a previous note [Abstr. 3730 (1952)] to the determination of the theoretical time constant of a long circular waveguide excited in the H_{01} mode. G. D. Sims

538.566

11228. Characterization of a direction of maximum gain and of stationary polarization for monochromatic electromagnetic radiation from an arbitrary system, at infinity. M. Bouix. *C.R. Acad. Sci.* [*Paris*] **239,** 35–7 (*July* 5, 1954) *In French.*

A theoretical discussion of the existence of directions of stationary polarization and their relation to the direction of maximum gain. G. D. Sims

538.566

11229. On multipole expansions in the theory of electromagnetic radiation. C. J. Bouwkamp and H. B. G. Casimir. *Physica*, **20,** 539–54 (*Aug.*, 1954).

A new method is developed for expanding the electromagnetic field of radiating charges and currents in multipole components. Outside a sphere enclosing all sources, the field is represented in terms of Debye potentials which are shown to be closely related to the radial components of the electric and magnetic vectors. Attention is drawn to remarkably simple source representations of these radial components. A discussion of vector-potential *versus* Debye-potential representation of multipole fields is included. Only familiarity with ordinary vector calculus is required. A.

538.566 : 621.396.67

11230. The fields of an oscillating magnetic dipole immersed in a semi-infinite conducting medium. J. R. Wait and L. L. Campbell. *J. geophys. Res.*, **58,** 167–78 (*June*, 1953).

The axis of the dipole is taken to be parallel to the interface between the conducting medium and the semi-infinite insulating space above it. Various special cases are discussed in detail and are illustrated by graphs. A.

538.566.2 : 621.3.013 : 621.396.67

11231. The fields of an electric dipole in a semi-infinite conducting medium. J. R. Wait and L. L. Campbell. *J. geophys. Res.*, **58,** 21–8 (*March*, 1953).

The behaviour of an electric dipole situated above a semi-infinite conductor is investigated. Expressions for the electric and magnetic fields within the conductor are derived for the case that significant distances are much less than a free space wavelength. Curves are plotted which show the dependence on conductivity, frequency, and position of the observer. The application of the results to propagation in sea-water is indicated. A.

538.566.2 : 621.396.11

11232. Reflection and refraction of electromagnetic waves in a stratified medium. K. Försterling. *Hochfrequenztech. u. ElektAkust.*, **63,** 112–16 (*April*, 1954) *In German.*

Expressions are found for the wave components. These involve the solution of a differential equation, and an approximate one is obtained. The reflection and absorption coefficients are calculated. The formulae are somewhat ponderous. L. S. GODDARD (R)

538.566.2

11233. Wave packets, the Poynting vector, and energy flow. IV. Poynting and Macdonald velocities in dissipative anisotropic media (conclusion). C. O. HINES. *J. geophys. Res.*, **56**, 535–44 (*Dec.*, 1951).

For Pt III, see Abstr. 8061 (1951). The common method of using the Poynting vector is extended to dissipative media. It is found preferable to replace Poynting's vector by Macdonald's to obtain physically suitable results, but even then the direction obtained for the energy flow shows a discrepancy with that found by packet methods. No conclusive decision can be reached, but argument appears to favour the packet as giving the observable energy flow. A.

538.566.2 : 621.396.11

11234. Electromagnetic-wave propagation over a plane homogeneous earth's surface. Y. NOMURA. *J. Inst. Elect. Commun. Engrs Japan*, **37**, 160–5 (*March*, 1954) *In Japanese.*

The saddle-point method is applied to show that the Sommerfeld surface-wave term due to the residue of the pole of the integrand is just cancelled by the part of the integral along the steepest descent through the saddle point, also that the remaining part of the integral gives the same formula as that of van der Pol and Niessen, which is the extension of Weyl's solution. The non-existence of the surface wave is attributed to the fact that the ratio of the propagation constants of the air and the earth, $|k/k_2|$, is so small that the pole of the integrand lies in the neighbourhood of $\lambda = k$, which is the branch point of $\sqrt{(\lambda^2 - k^2)}$.

A. WILKINSON

538.566.2 : 621.396.11

11235. The extension of Sommerfeld's formula for the propagation of radio waves over a flat earth, to different conductivities of the soil. H. BREMMER. *Physica*, **20**, 441–60 (*Aug.*, 1954).

The influence of non-homogeneous soil conditions on the propagation of radio waves over a flat earth can be investigated with the aid of an integral equation based on Green's theorem. This equation applies to all types of distributions (also continuous) of the conductivity and of the dielectric constant of the earth; it is essentially identical with the integral equation considered by Hufford for the propagation over irregular terrain. The special solution for two adjacent regions of homogeneous electrical constants can be treated numerically with the aid of two different expansions for the field near the separating boundary and for the field far beyond this boundary; the rigorous solution of the integral equation proves to be identical with the corresponding expression derived in a very different way by Clemmow. The solution for three adjacent homogeneous regions can be obtained by solving the general integral equation by a similar method. A.

538.566.3

11236. Wave propagation in an anisotropic, inhomogeneous medium. J. FEINSTEIN. *J. geophys. Res.*, **58**, 223–30 (*June*, 1953).

The results of wave theoretical calculations for the characteristic mode polarizations and reflection coefficients in the presence of finite gradients of electron density and arbitrarily oriented geomagnetic field are presented. Consideration of the variation of the polarizations with distance within the medium leads to a simple interpretation of the departures from geometric optics on the basis of wave-theory principles. The treatment is extended to the vicinity of the critical collisional frequency at which the transition from quasi-transverse to quasi-longitudinal propagation is expected to occur on ray theory; modifications introduced by the wave principles are discussed. The conclusions are applied to afford an explanation of low-frequency polarization measurements. A.

538.566.3

11237. Optic axes and critical coupling in the ionosphere. N. DAVIDS. *J. geophys. Res.*, **58**, 311–21 (*Sept.*, 1953).

Critical coupling arises when, for a certain critical $N = N_c$ and $\nu = \nu_c$ the coupling factor, which measures the degree of interaction between the ordinary and extraordinary modes, becomes infinite. Instead of attempting to solve the standard coupled wave equations at or near this singularity, a different reference system is introduced based on the principal directions of the three-dimensional dielectric ellipsoid. These directions depend only on the direction of the earth's field, and are thus essentially constant over the ionosphere. Analogy with crystals, as pointed out by Lange–Hesse, suggests the possibility of optic axes in the ionosphere. It is shown here that such axes can exist in the presence of collisions and that this is precisely the condition for critical coupling. The ionosphere acts isotropically at such a level, with no principal modes being singled out. Some application to data at 150 kc/s is made. A.

538.566.3

11238. A reciprocity theorem on the propagation of radio waves via the ionosphere. K. G. BUDDEN. *Proc. Cambridge Phil. Soc.*, **50**, *Pt* 4, 604–13 (1954).

The reciprocity theorem for electrical systems which include a radiation link was believed to be true only when the media within the system have dielectric constants which are symmetric tensors. This condition is not fulfilled by the ionosphere, so that the reciprocity theorem is not generally applicable when the radiation link includes one or more reflections from the ionosphere. It is here proved that, when the ionosphere is horizontally stratified, and when the path from transmitter to receiver is in the magnetic meridian (north-south and south-north transmission), the reciprocity theorem applies (*a*) when the transmitting and receiving aerials both radiate or receive waves whose electric vector is in the plane of incidence, and (*b*) when both aerials radiate or receive waves whose electric vector is horizontal. Further, (*c*) if the electric vector radiated or received is horizontal for one aerial and in the plane of incidence for the other, then there is reciprocity in signal amplitude, but the phase changes for transmission in the two directions differ by 180°. These results are valid for any law of variation of electron density and collision frequency with height. They are based on a "full-wave" theory, and therefore apply to all frequencies. They are unaffected if the path includes multiple reflections, and if allowance is made for the curvature of the earth. A.

538.566.3

11239. ***F*-region triple splitting.** G. R. ELLIS. *J. atmos. terrest. Phys.*, **3**, 263–9 (*June*, 1953).

Measurements of the direction of arrival of *Z* echoes have been made at Hobart, Tasmania. The results indicate that *F*-region triple splitting is caused by back scattering from a rough layer. The directions observed are consistent with the assumption that reflection at the *Z* level occurs when the angle of incidence is such that the wave normal becomes parallel to the geomagnetic field at the ordinary level of reflection. A.

538.566.3

11240. Universal wave polarization chart for the magneto-ionic theory. W. SNYDER AND R. A. HELLIWELL. *J. geophys. Res.*, **57**, 73–84 (*March*, 1952).

The expression for complex polarization given by the magneto-ionic theory has been plotted on the complex plane using normalized parameters related to ionization density and collisional frequency. Booker's definition of ordinary and extraordinary rays is used. This results in the entire realm of ordinary polarizations lying inside the unit circle. The symmetry of the chart is such that all desired information can be extracted from the first quadrant which is plotted in detail. Since experimental data are obtained in the form of ellipticity and tilt angle, another chart has been included relating these quantities to the same normalized parameters as appear on the complex polarization chart. To complete the graphical presentation, a nomogram has been included that aids in converting the normalized parameters on the two polarization plots to the corresponding ionization density and collisional frequency. A.

538.566.3

11241. Wave solutions, including coupling, or ionospherically reflected long radio waves for a particular *E*-region model. J. J. GIBBONS AND R. J. NERTNEY. *J. geophys. Res.*, **57**, 323–38 (*Sept.*, 1952).

An extension of previous work [Abstr. 1988 (1952)]. The method of "variation of parameters" is used to obtain approximate solutions to the coupled equation from the uncoupled solutions obtained previously. A diurnal and seasonal model representing the *E*-region of the ionosphere above State College, Pennsylvania, is considered. This model consists of a Chapman-like *E*-region whose maximum in electron density is at a constant height. Approximate 150 kc/s wave solutions including coupling are obtained for this model. These wave solutions, of course, exhibit the well-known reflection condition corresponding to an electron density of around 3000 electrons/cm^3. It is shown that the effect of the coupling is to cause a wave traversing a coupling region to excite a new wave propagated in the direction of propagation of the incident wave and also a back-scattered wave propagated in the reverse direction; these coupling effects become important below the "reflection" level. The back-scattered wave due to the initial upgoing wave will thus appear as a reflected wave originating in the coupling region. The forward-scattered wave due to the downgoing wave from the upper "reflection" level also must be considered, particularly in calculating the polarization of ionospherically reflected waves. It is shown that, in the case of 150 kc/s waves, the coupling effects occur in the neighbourhood of $N = 300$ electrons/cm^3, which corresponds to the "classical reflection" level for the "ordinary" wave. The coupling effects become greater as the collisional frequency, ν, associated with the coupling N value decreased toward the critical collisional frequency, ν_c, for the night-time models due to the increase in heights of the "bottom" of the layer at these times. This results in stronger split echoes and greater departure from circularity in the polarization ellipses. The results of computations utilizing the theory, in comparison with experimental results, indicate that the stratification observed in the height records may be explained as outlined above. The absorption and polarization experimental results, however, cannot be accounted for by the *E*-region model utilized alone. The consideration of an electronic *D*-region, however, readily accounts for all three experimental factors. A.

538.566.3

11242. On the solar influence on gyrointeraction experiments. G. RIGHINI AND G. GODOLI. *Ann. Geofis.*, **6**, 11–19 (*Jan.*, 1953) *In Italian.*

Any solar influence on gyrointeraction is shown to be extremely improbable. A.

538.566.3

11243. Magneto-ionic multiple splitting determined with the method of phase integration. W. PFISTER. *J. geophys. Res.*, **58**, 29–40 (*March*, 1953).

The method used is a first-order WKB approximation with an integration path in the complex height plane. The refractive index *v.* height is represented on a Riemann surface with four sheets corresponding to upgoing and downcoming waves and ordinary and extraordinary types of polarization. The branch points connecting the sheets are characterized as reflection points or as coupling points. Suitable paths of integration in the Riemann surface determine the reflection coefficient for the various magneto-ionic components. Five possible fundamental components have been found, and an infinite number of additional components due mainly to multiple reflections between the different reflection points. Numerical computations have been carried out for one ionospheric model with a Chapman distribution of electrons and an exponential decrease of collision frequency located in a moderate magnetic latitude. The results are represented in a sweep frequency picture of virtual height and absorption for five fundamental modes of propagation. A.

538.566.3

11244. Concerning Green's reinterpretation of the magneto-ionic theory. C. G. MCCUE. *J. atmos. terrest. Phys.*, **3**, 239–44 (*June*, 1953).

Green's reinterpretation of the magneto-ionic theory is examined critically and is shown to be incorrect. The corrections to maximum usable frequency forecasts due to the neglected effects of the earth's magnetic field and collisions are discussed briefly. A.

538.566.3 : 551.510.535

11245. On the coupled wave equations of magneto-ionic theory. J. M. Kelso. *J. geophys. Res.*, **58,** 431–6 (*Dec.*, 1953).

The propagation of a plane radio wave incident vertically on an inhomogeneous ionosphere varying in the vertical direction in the presence of the terrestrial magnetic field is characterized by a pair of coupled wave equations. These equations can be changed in appearance by choosing various different forms for the time factor, co-ordinate system, particle charge and wave-functions. In the recent literature, this has led to some unfortunate confusion, which the present work is intended to clarify. The wave equations and the basic defining relations are presented in such a way as to show explicitly the effects of some of the possible arbitrary choices noted above. A table comparing the present notation with that used by various other authors is given. A.

538.566.3 : 551.510.535

11246. Real and complex wave polarization in the ionosphere. J. C. W. Scott. *J. geophys. Res.*, **58,** 437–43 (*Dec.*, 1953).

The relation between the polarization ellipse in the wave front and the complex polarization at vertical incidence in a slowly-varying horizontally-stratified ionosphere is reviewed. Charts and a table are given showing the sense, orientation and eccentricity of the polarization ellipse under all conditions of plasma frequency, collisional frequency, wave frequency and magnetic field intensity and direction. A.

538.566.3 : 621.396.11

11247. Higher-order approximations in ionospheric wave propagation. C. O. Hines. *J. geophys. Res.*, **58,** 95–8 (*March*, 1953).

Because of non-linearities in the basic equations governing ionospheric wave propagation, the usual (perturbation) treatment involving a single frequency of oscillation does not provide a complete solution. The difficulty has been previously treated by the introduction of harmonics but, because of a misinterpretation of the mathematical symbolism, the results are not immediately applicable to the physical problem for which they were intended. A corresponding treatment, physically more appropriate, is undertaken here. Certain results of the earlier enquiry—in particular, those concerning resonance—are regained at some levels of approximation, but their general validity is doubtful. A.

538.567 : 537.521

11248. Effect of elastic collisions between electrons and molecules on longitudinal electric waves in the plasma. M. E. Gertsenshteĭn. *Zh. éksper. teor. Fiz.*, **24,** *No.* 6, 652–8 (1953) *In Russian.*

Analyses the effect of the active energy losses caused by elastic collisions between electrons and molecules on the propagation of the longitudinal waves in the plasma [see also Abstr. 5921–2, 7307 (1952)]. In particular, an explanation is given for the wide divergence between theory and experiment for the depth of penetration of longitudinal waves into the plasma. A simplified form of writing the collision integral in the case of volume charges is given. It is shown that the active losses caused by collisions are insignificant if the phase velocity of the longitudinal wave is small. F. LACHMAN

MAGNETIC EFFECTS 538.6

538.632/.633

11249. Direct comparison of the Hall effect and the Corbino effect. W. J. Poppelbaum. *Helv. phys. Acta,* **27,** *No.* 4, 355–94 (1954) *In French.*

A new method of measuring the Hall effect, derived from that of Corbino, is described: a cylindrical sample is immersed in a radial magnetic field, which produces a transverse current when an alternating voltage is applied between the ends of the cylinder. This transverse current gives rise to an induced voltage in a coaxial coil. Certain design characteristics of the electromagnet make possible induced voltages as high as one volt for an axial current of 100 A and a field of $0\cdot3$ Wb/m^2. The fact that a cylinder is a plate which is closed on itself also permits measuring the Hall effect by a method derived from that of Hall himself: transverse currents are induced by the coaxial coil, their intensity being determined by calorimetric methods; these induced currents produce an axial Hall voltage. Thus for the first time the Corbino effect (transverse component of current with fixed direction of electric field) and the Hall effect (transverse voltage with fixed direction of current) can be measured on the same sample. This gives two independent means of determining the Hall constant R. When errors due to inhomogeneous magnetic fields, position of probes and thermal effects are taken account of, the coincidence of the two values of R is better than 5%. In a theoretical introduction Meixner's linear relations between electric and thermal fields and currents for nearly stationary states are established. A.

538.639 : 538.24

11250. Further correlation between magnetoresistance variations and the de Haas–van Alphen effect. T. G. Berlincourt and J. K. Logan. Letter in *Phys. Rev.*, **93,** 348 (*Jan.* 15, 1954).

The curve of increase of resistance of a graphite crystal as a function of magnetic field at 4·2°K shows slight humps which have a uniform period in $1/H$ equal to that of the de Haas–van Alphen effect. D. SHOENBERG

538.653.1

11251. The remanence and magnetic coercivity of nickel subjected to longitudinal compression. S. Velayos. *An. Real Soc. Españ. Fís. Quím.*, **50(A),** 99–104 (*May–June*, 1954) *In Spanish.*

An experimental study has been made by a ballistic method on the influence of a longitudinal compression on the magnetic coercivity and retentivity of a pure nickel rod. The large effect of compression on the shape of the hysteresis loop was checked. Retentivity increases with increasing compression and values were interpreted in a qualitative way by means of domain theory. The coercivity decreases with increasing compression. A large applied compression causes strains, internal strains, in addition to the normal elastic strain, and then increases the average internal stress. This fact is not displayed by the retentivity and this confirms that the coercivity is perhaps one of the most structure-sensitive properties of magnetic materials. A.

MOLECULAR AND ATOMIC STRUCTURE 539.1

THEORY OF SOLID STATE 539.11

539.11

11252. Pure quadrupole spectra in solids. R. LIVINGSTON. *Science*, **118**, 61–6 (*July* 17, 1953).

A general review. D. H. WHIFFEN

539.11

11253. Thermal and mechanical behaviour of amorphous solids as a result of molecular transposition. II. W. HOLZMÜLLER. *Z. phys. Chem.* [*Leipzig*] **203**, 163–80 (*Aug*., 1954) *In German.*

The statistics developed in Pt I [Abstr. 6762 (1954)] are used to investigate the influence of external fields and forces on the transposition of molecules. A formula, which is in agreement with experiment, for the viscosity (with modification also for structural viscosity) is derived. The treatment accounts for the characteristic exponential variation with temperature of relaxation time in relaxation processes. W. GOOD

539.11

11254. Theory of scattering in solids. G. F. KOSTER. *Phys. Rev.*, **95**, 1436–43 (*Sept.* 15, 1954).

The scattering of an electron by an imperfection in a lattice is set up in terms of a linear combination of the Wannier functions associated with the lattice. The difference equations which the coefficients of the Wannier functions satisfy are discussed in the light of simple examples. A Green's function formulation of the difference equations is then introduced which leads to the proper asymptotic behaviour of the scattered wave. This approach avoids many of the unwarranted assumptions usually made in the discussion of scattering in solids. A.

539.11

11255. Vibrational anharmonicity and lattice thermal properties. J. S. DUGDALE AND D. K. C. MACDONALD. *Phys. Rev.*, **96**, 57–62 (*Oct.* 1, 1954).

It has been believed for some time that anharmonicity of lattice vibrations is responsible for the continued rise of the specific heats of certain solids in the classical temperature region. A general analysis is here carried out of the linear chain model interacting through a Morse potential. All the major thermal properties, such as specific heats, thermal expansion and compressibility are derived, and a tentative comparison is made with observed properties of the alkali metals. It is found that the linear chain then exists in two widely different states with properties characteristic of condensed and gas-like phases; these two states are separated by a relatively narrow transition region in temperature where the specific heat passes through a rather sharp maximum (except at high pressures when the maximum ultimately disappears). A.

539.11 : 536.7

11256. Thermodynamics of phase transitions in compressible solid lattices. O. K. RICE. *J. chem. Phys.*, **22**, 1535–44 (*Sept.*, 1954).

The calculations on the Ising lattice and the order-disorder phenomenon indicate that the specific heat may become infinite at the λ temperature or transition point. The general thermodynamics of such a system in a variable magnetic field is considered, and the relation to the generalized theories of critical points of Tisza and of Semenchenko is indicated. The general import of these theories is that infinite values of the heat capacity at constant pressure C_p, or the analogous heat capacity in a system with variables other than p, V and T, can become infinite in a one-phase system only at a critical point. The existence of a locus of points where $C_p = \infty$ is thermodynamically possible in the pVT system, and equations analogous to the Clapeyron and Ehrenfest equations may be derived. However, the thermodynamic requirements show that such a locus is not likely to occur. Interesting possibilities occur where there is an interaction between several sets of variables. If an Ising lattice is compressible, for example, the transition temperature will depend on the lattice distance. In this case, the infinite heat capacity is to be considered as a singularity in C_v rather than in C_p. The effect of the compressibility is to change any transition in which infinite specific heats occur to a first-order transition. If there is already a first-order transition, even for an assumed incompressible lattice, the introduction of compressibility increases the latent heat and a discontinuity in lattice distance appears. This situation appears to arise in the order-disorder transformation of an alloy like $AuCu_3$, and the phases may also be expected to have different compositions; this latter phenomenon has also been considered from the point of view of this paper. If there is a λ point without infinite specific heats, the introduction of compressibility may or may not change it to a first-order transition; in any event, the λ point is made "sharper." There may be a critical point in this case. Various thermodynamic relationships are deduced, and the nature of the isotherms in all these cases is considered. A.

539.11 : 548.7

11257. Linear relations between Madelung constants. F. BERTAUT. *C.R. Acad. Sci.* [*Paris*] **239**, 234–5 (*July* 19, 1954) *In French.*

The analytical methods of Abstr. 5775 (1953) are used to show that there are linear relations between the Fourier transforms of the Patterson functions, and hence between the Madelung constants, of simple cubic lattices of different parameter. Inspection of data confirms this, e.g. $M(CaF_2) - 2M(ZnS) - M(CsCl) = 0$. J. HAWGOOD

MOLECULAR STRUCTURE 539.13

539.13

11258. The forces between polyatomic molecules. S. D. Hamann, W. J. McManamey and J. F. Pearse. *Trans Faraday Soc.*, **49**, 351–7 (*April*, 1953).

The second virial coefficients of SiF_4, SF_6, C_2N_2 and propadiene have been measured. The potential energies between polyatomic molecules are discussed in the light of these results. A.

539.13

11259. Long range forces between large chain molecules. C. A. Coulson and P. L. Davies. *Trans Faraday Soc.*, **48**, 777–89 (*Sept.*, 1952).

A study is made of the dispersion forces between extended oscillators, such as occur in conjugated molecules. The variation of dispersion energy with distance apart obeys the London inverse sixth-power law only at large separations. At small separations the index sometimes drops as low as 3·5. A discussion is given of the way in which the dispersion energy varies when one of the molecules is displaced relative to the other. These forces do not appear to possess any highly specific properties, such as are required in many biological systems. A.

539.13 : 533.7

Intermolecular forces causing solubility in compressed gases. *See Abstr.* 10893–4

539.132 : 548.7

11260. Calculation of wave functions in a symmetrical crystalline field. P. H. E. Meijer. *Phys. Rev.*, **95**, 1443–9 (*Sept.* 15, 1954).

It is possible to calculate the splitting of the energy levels of an ion caused by a crystalline field of a certain symmetry in a more systematic way. Instead of solving the secular equation, certain algebraic quantities, i.e. the idempotent elements of the ring of the group, are introduced which contain all the information that can be obtained from the symmetry. This makes it possible to state, before other physical arguments are introduced, how many parameters enter a particular problem. In order to make the method easy to handle, some tables have been added, and a special case has been worked out. A.

539.132 : 536.66

11261. Heats of combustion and molecular structure. I. The resonance energy and structure of cyclo-octatetraene. H. D. Springall, T. R. White and R. C. Cass. *Trans Faraday Soc.*, **50**, 815–19 (*Aug.*, 1954).

An experimental combustion calorimetry procedure is described and the method of deriving molecular energetics from combustion calorimetric data is recorded. The evidence for the molecular structure of cyclo-octatetraene is reviewed in the light of the molecular energetics of this substance. A.

539.132 : 536.66

11262. Heats of combustion and molecular structure. II. The mean bond energy term for the carbonyl system in certain ketones. H. D. Springall and T. R. White. *J. Chem. Soc.*, **1954**, 2764–6 (*Aug.*).

The heats of combustion ($-\Delta H_c^0$) of diacetyl, benzil, benzyl methyl ketone and dibenzyl ketone, together with the corresponding latent heats of evaporation (or sublimation), L_g^{st}, have been determined, and used to derive the mean bond energy terms for the carbonyl system, $\bar{E}(C{=}O)$, in these compounds. The significance of these results is briefly considered. A.

539.132

11263. Vibrations and force constants of phosphorus. N. B. Slater. *Trans Faraday Soc.*, **50**, 207–9 (*March*, 1954).

The use of internuclear distances as sole co-ordinates for molecular vibrations is illustrated by a calculation of a complete set of force constants for the P_4 molecule. A.

539.132

11264. Force constants for the BF_3 molecule. V. Santhamma. *Proc. Nat. Inst. Sci. India*, **20**, 245–51 (*May–June*, 1954).

Wilson's F–G matrix method has been applied to determine the force constants for the plane symmetrical molecule BF_3. The set of the force constants thus obtained are used to determine the vibrational frequencies of the isotopic molecule $B^{10}F_3$. A.

539.132

11265. The dependence of bond energy on bond length. L. Pauling. *J. phys. Chem.*, **58**, 662–6 (*Aug.*, 1954).

It is suggested that in a series of similar bonds the bond energy is proportional to the reciprocal of the equilibrium interatomic distance (the bond length). This relation is supported by experimental values for some sequences, such as O_2, S_2, Se_2, Te_2. Application of the relation to other sequences is shown to support the values 170 kcal/mole for the heat of dissociation of N_2 and 139 kcal/mole for the heat of sublimation of carbon. The dependence of bond energy on other factors, including character of bond orbitals, energy of resonance of bonds among alternative positions and repulsion of unshared electron pairs on the bonded atoms, is discussed. A.

539.132

11266. Dissociation energy of N_2. J. M. Hendrie. *J. chem. Phys.*, **22**, 1503–7 (*Sept.*, 1954).

An attempt has been made to observe the thermal dissociation of N_2 in order to choose between the two values, 7·385 eV and 9·765 eV, for the dissociation energy of N_2. At the highest available temperatures no dissociation could be observed, and a lower limit of 8·80 eV is set for $D(N_2)$. A.

539.132 : 536.7

11267. Force constants and thermodynamic properties of $TiCl_4$. D. Tirumalesa and V. Ramakrishna Rao. *Indian J. Phys.*, **28**, 216–20 (*May*, 1954).

Sets of force constants are calculated for the $TiCl_4$ molecule by using the known fundamental frequencies and Wilson's normal co-ordinate treatment. By comparing the results with data from other sources, one particular set of constants is recommended. The heat content, free energy, entropy and heat capacity of this molecule are calculated for a harmonic oscillator, rigid rotator approximation for temperatures varying from 100°K to 1000°K. A.

539.132

11268. Torsional vibrations of long chain molecules. II. The torsional polarization of isolated long chain ketone molecules in the extended configuration. B. Szigeti. *Trans Faraday Soc.*, **48**, 400–9 (*May*, 1952).

For Pt I, see Abstr. 2863 (1952). Long chain molecules are considered in the extended configuration, and the interaction between molecules is neglected. The out-of-plane vibrations consist of a superposition of a translational and a rotational motion; the relation between the amplitudes of these two is derived. For long chain ketones, with the CO group near the centre of the chain, the mean square amplitude of the torsional vibration of the CO group is calculated. At any particular temperature this is approximately proportional to the chain length. The polarizability of ketones connected with the torsional vibrations is calculated and turns out to be very large compared with the usual effect of internal vibrations. Although this polarizability is contributed by harmonic internal vibrations, it nevertheless forms part of that term in the total polarizability which is usually called the orientational polarization. A.

539.132

11269. Torsional vibrations of long chain molecules. III. The effects of the chain ends. B. Szigeti. *Trans Faraday Soc.*, **49**, 132–40 (*Feb.*, 1953).

For isolated long-chain ketones in the extended configuration, with the CO group near the centre of the chain, the effect of the chain ends on the amplitude of the torsional oscillations of the CO group is calculated. It is found that the importance of these end effects does not diminish with increasing chain length. If the number of carbon atoms is odd, then for the model discussed, the mean square amplitude of the CO group differs by about a factor 2 according to whether it is on the same side of the chain axis as the end groups or opposite to them. The frequencies of vibration are probably not much influenced by these effects. A.

539.132

11270. The rotational constants of monodeuteromethane. D. R. J. Boyd and H. W. Thompson. *Trans Faraday Soc.*, **49**, 1281–4 (*Nov.*, 1953).

The experimental data on a parallel-type vibration-rotation band of monodeuteromethane which were partially analysed previously [Abstr. 3495 (1953)] have been examined further. It has been shown that an apparent anomaly can be explained by taking into account further centrifugal stretching terms in the rotational energy function, and it has now been possible to obtain values for D'_{JK} and D''_{JK} in addition to the constants B', B'', D'_J and D''_J. The values for D''_J and D''_{JK} for molecules of the type CH_3X are shown to form a regular series both in relation to each other and to B''. The correlation serves to correct one value derived from the microwave spectrum of methyl fluoride. In monodeuteromethane, r_0(C–H) = $1\cdot0935_6$ Å. A.

539.132

11271. Spectroscopic constants of molecules. II. On the vibration frequencies of diatoms of the type XY. K. Majumdar and Y. P. Varshni. *Indian J. Phys* **28**, 209–15 (*May*, 1954).

For Pt I, see Abstr. 9468 (1954). Relation of th vibration frequency of diatom XY with the vibratio frequencies of diatoms XX and YY has been studie X and Y belonging to the same group of the periodi table. If $\omega_e^{0\cdot65}$ for XY be represented by ϕ (XY), the it is found that $\phi(XY) = [\phi(XX) + \phi(YY)]/2$. Th calculated values are in good agreement with th observed values. Many undetermined frequencie have been predicted. A

539.13

11272. Effect of the solvent on the NH frequency o pyrrole. Comparison with the effect of the solvent o the OH frequency in methanol and phenol. N. Fuso and M. L. Josien. *J. Phys. Radium*, **15**, 652– (*July–Aug.–Sept.*, 1954) *In French.*

The NH frequency in the region 3200–3500 cm^{-} was studied. $(\nu_v - \nu_s)/\nu_v$ (ν_v and ν_s are the valence frequencies in the vapour and in solution respectively) was in non-polar solvents proportional to $(D - 1)/(2D + 1)$, D being the dielectric constant of the solvents (relation of Kirkwood and Bauer). The constant of proportionality varies little between —NH and —OH compounds. A. J. TAYLOR

539.132

11273. The NH, CO and CH_2 frequencies in benzocarbazoles, benzofluorenones and benzofluorenes. M. L. Josien and N. Fuson. *J. Phys. Radium*, **15**, 654–6 (*July–Aug.–Sept.*, 1954) *In French.*

These frequencies decrease with increasing number of benzene rings added to pyrrole, cyclopentadienone and cyclopentadiene (by about 1% for 4 added rings), but there is an "angle effect" causing differences between isomers of different shape. J. HAWGOOD

539.132

11274. Relationship between frequency and structure in ketones and aldehydes. M. Scrocco and A. Liberti. *Ricerca sci.*, **24**, 1687–94 (*Aug.*, 1954) *In Italian.*

Series of aldehydes and ketones have been examined by infrared spectroscopy. Variations of the fundamental vibration frequency of the C=O band with the resonance energy of the molecules and with the constant of Hammet's equation is interpreted in terms of stabilization and reactivity of the molecules. A.

539.132

11275. Rotational constants of SiH_3D. S. R. Polo and M. K. Wilson. *J. chem. Phys.*, **22**, 1559–61 (*Sept.*, 1954).

The analysis of the rotational structure of the Si–D stretching fundamental yields the following values: $B'' = 2\cdot11 \pm 0\cdot01$ cm^{-1}, $B'' - B' = 0\cdot019$ cm^{-1}, $\nu_0 = 1594\cdot4 \pm 0\cdot1$ cm^{-1}. The value of the Si–H distance obtained under the assumption that it remains unchanged by isotopic substitution is $d_{\text{Si}-\text{H}} = 1\cdot47_7 \pm 0\cdot003$ Å. A.

539.132

11276. The vibrational and rotational excitation of molecular hydrogen by electron impact. T. R. Carson. *Proc. Phys. Soc.* [*London*] *A*, **67**, 909–16 (*Oct.*, 1954).

The Born approximation is applied to the collision of electrons with normal hydrogen molecules. Cross-sections are calculated for collisions accompanied by the vibration-rotation transitions $0, 0 \rightarrow n, l\,[(n = 0, 1), (l = 0, 2, 4)]$ for incident electron energies between 0 and 250 eV. Special attention is given to the choice of the interaction potential, the form of which has a marked effect upon the pure vibrational excitation function in the low-energy region where a sharp peak appears. The rotational excitation does not show the same sensitivity. Elastic scattering is also treated and the results are in satisfactory agreement with those of previous workers. A.

539.132 : 535.338.4

Computation of intensities of vibrational spectra of electronic bands in diatomic molecules. *See Abstr.* 10944

539.132 : 535.343.4–15

11277. Vibration-rotation bands and rotational constants of cyanogen and diacetylene. G. D. Craine and H. W. Thompson. *Trans Faraday Soc.*, **49**, 1273–80 (*Nov.*, 1953).

The rotational fine structure of a vibration band of cyanogen has been resolved. This band at $4 \cdot 63\ \mu$ shows P and R branches with an alternation of intensities, confirming the linear symmetric structure with nuclear spin of the identical nitrogen nuclei. Although the band is overlapped by at least one hot transition, a rotational analysis has been carried out, leading to the value $B'' = 0 \cdot 1588\ \text{cm}^{-1}$, and $\alpha_3 = (B'' - B') = 5 \cdot 3_2 \times 10^{-4}\ \text{cm}^{-1}$. There is some uncertainty in the value of D'' obtained, but it must be less than about $10^{-7}\ \text{cm}^{-1}$. Assuming that $r_{\text{CN}} = 1 \cdot 157$ Å, $r_{\text{CC}} = 1 \cdot 36_8$ Å, which lies in the middle of the range of values determined by electron diffraction. Two other bands of cyanogen have been measured, but appear to have a complex structure. An analogous band of diacetylene at $4 \cdot 94\ \mu$ has also been resolved into rotational structure and rotational constants have been obtained. $B'' = 0 \cdot 1464\ \text{cm}^{-1}$, and $\alpha_5 = 0 \cdot 000398$, the latter differing from another estimate recently made from some bands in the photographic infrared by an amount which suggests some form of vibrational interactions among the upper levels. Assuming probable values for r_{CH} and $r_{\text{C}\equiv\text{C}}$, r_{CC} is found to be $1 \cdot 38$ Å. A.

539.132

11278. Calculation of perturbations in certain molecular electronic terms. I. $^2\Sigma - {}^4\Pi$. D. Premaswarup. *Indian J. Phys.*, **28**, 256–62 (*June*, 1954).

Expressions are derived for the course of energy levels at the point of intersection of two mutually perturbing molecular electronic states. The method of treatment is given in detail and applied to the perturbation $^2\Sigma - {}^4\Pi$. A.

539.132

11279. Calculation of the absorption spectra of some dyes by the metallic model taking into account the ramifications of the metallic chains. S. Nikitine and S. G. el Komoss. *J. Phys. Radium*, **15**, 536–8 (*June*, 1954) *In French.*

In calculations on some dyes whose conjugated chains include complete cycles, the metallic model is modified to take account of this. This change, and the use of the "$M-1$ electron method" (2 of the free electrons regarded as bound in the potential trough round the N atoms), make agreement with experiment much better than for the unmodified linear model and the "$M+1$ electron method." See Abstr. 3505–6 (1953). J. HAWGOOD

539.132 : 535.338.4

On the working of some theories of vibrational transition probabilities. *See Abstr.* 10945

539.132

11280. Magnetic resonance spectrum of a linear three-spin system: the configuration of the bifluoride ion. J. S. Waugh, F. B. Humphrey and D. M. Yost. *J. phys. Chem.*, **57**, 486–90 (*May*, 1953).

The nuclear magnetic resonance spectrum is calculated for a system of three nuclei of spin $\frac{1}{2}$, two of which have identical g factors. The results are applied to a study of the bifluoride ion in KHF_2, and comparisons with experiment are made for both proton and fluorine resonances The data obtained, together with a study of the second moment of the fluorine resonance, confirm a symmetrical structure for the ion, the proton being found to lie within $\pm 0 \cdot 06$ Å of the ion centre. Second moment data on the fluorine resonance in NaHF_2 permit a partial determination of the HF_2^- structure in that substance. A.

539.132

11281. Pure quadrupole spectra of solid chlorine compounds. R. Livingston. *J. phys. Chem.*, **57**, 496–501 (*May*, 1953).

Quadrupole couplings have been determined for a number of covalently bonded chlorine compounds that form molecular crystals. Multiple resonances due to non-equivalent Cl lattice positions, resonances for the two stable Cl isotopes and the variation of resonance frequency with temperatures down to 4°K are briefly discussed. A comparison of quadrupole couplings gives a measure of the variation from one molecule to another of the electric field gradient experienced by the chlorine nuclei. Such comparisons are given for the chloromethanes, "Freons," chloroethanes and related compounds. A number of quadrupole coupling values determined in the solid are compared with microwave values found for the gas. A.

539.132

11282. Pure quadrupole spectra of molecular crystals. H. C. Allen, Jr. *J. phys. Chem.*, **57**, 501–4 (*May*, 1953).

Two r.f. spectrometers suitable for investigation of pure quadrupole spectra are described. The first of these is a frequency-modulated super-regenerative spectrometer which has a workable range of 20–40 Mc/s. The second spectrometer is a simple regenerative Zeeman modulation spectrometer with a workable range of 1–40 Mc/s. Information which can be obtained from pure quadrupole spectra of solids, such as intermolecular hydrogen bonding, phase transition detection, electron withdrawal ability of substituent groups and the correlation of Hammett's σ with the quadrupole coupling frequencies are discussed. Preliminary reports are made of the effect of substituting deuterium for hydrogen on the chlorine quadrupole coupling frequencies in two compounds. A.

539.132

11283. Paramagnetic resonance absorption of free radicals. T. L. Chu, G. E. Pake, D. E. Paul, J. Townsend and S. I. Weissman. *J. phys. Chem.*, **57**, 504–7 (*May*, 1953).

The paramagnetic resonance behaviour of a set of polyatomic free radicals is discussed. The effects of exchange, dipolar interactions and relaxation mechanism on line shapes are sketched. The appearance of hyperfine splittings in dilute solution of certain free radicals and the inferences which can be drawn from the splittings are presented. A.

539.132

11284. Paramagnetic resonance in the solid state. B. Bleaney. *J. phys. Chem.*, **57**, 508–17 (*May*, 1953).

In paramagnetic resonance, magnetic dipole transitions are observed between the various Zeeman components of a given atomic level. In a field of a few thousand gauss such transition lines occur at wavelengths of a few centimetres, and they may be used to investigate the magnetic properties of ions of the transition elements in the solid state. Such properties comprise the spectroscopic splitting factor *g*, fine structure of the Zeeman levels and hyperfine structure when the nucleus of the paramagnetic ion has a non-zero spin. Both *g* and the h.f.s. are anisotropic, their magnitude depending on the direction of the external magnetic field relative to the crystal axes, and a separate spectrum is observed from each type of ion. Much more detailed information is therefore obtained than from susceptibility measurements, which are determined by the gross effect of all types of ion. The transition groups principally investigated are the 3*d* and 4*f* groups. Of special chemical interest is information on the binding of copper salts and complex salts such as cyanides of the type $K_3Fe(CN)_6$. Preliminary work on other transition groups (4*d*, 5*d*, 5*f*-6*d*) is reported. A.

539.132

11285. Quadrupole resonance of Cl^{35} in *p*–$C_6H_4Cl_2$ at low temperatures. D. Dautreppe, B. Dreyfus and M. Soutif. *C.R. Acad. Sci.* [*Paris*] **238**, 2309–11 (*June* 14, 1954) *In French.*

The quadrupole resonance of *p*–$C_6H_4Cl_2$ is followed from 300–0°K but is not in full agreement with the theory of Bayer [Abstr. 1170 (1952)], but the variation of the spin-lattice relaxation time, T_1, with temperature is in agreement with the theory of Ayant (thesis, in press). D. H. WHIFFEN

539.132

11286. Variation in the quadrupole coupling constant with vibrational state in the methyl halides. J. Kraitchman and B. P. Dailey. *J. chem. Phys.*, 1477–81 (*Sept.*, 1954).

The $J = 0 \rightarrow 1$ microwave rotational transitions in the states $v = 1$ of the vibrations $\nu_3(a_1)$ and $\nu_6(e)$ in methyl chloride and the state $v = 1$ of the vibration $\nu_3(a_1)$ in methyl bromide have been studied. The quadrupole coupling constants *eqQ* of chlorine and bromine in these states were determined. These were compared with the values determined for the ground state. No variation of the quadrupole coupling constants with vibrational state was observed. The accuracy of the measurements requires the variation of *eqQ* with vibrational state to be less than 0·07% in methyl bromide. The rotational constants and vibration-rotation constants for these states were also determined. A.

539.132 : 541.5

11287. The chemical significance of quadrupole spectra. B. P. Dailey. *J. phys. Chem.*, **57**, 490–6 (*May*, 1953).

The deviation of certain nuclei, such as Cl, Br, I and N from a spherical shape gives rise to an energy of orientation of the nucleus with respect to the molecular or crystalline electric field in which the nucleus is located. This gives rise to a characteristic pattern of energy levels, dependent on nuclear and molecular parameters, which is described. The electrostatic interaction between the nucleus and the molecule exerts a torque on the molecule which modifies its pattern of rotational energy levels, giving rise to a hyperfine structure. The resulting modification of the rotational spectra is discussed. The quantity *eqQ* may be experimentally determined either from direct quadrupole spectra in the region of 10–1000 Mc/s or from the quadrupole hyperfine structure in microwave rotational spectra. The experimental techniques used are briefly outlined. The values of *eqQ* may be interpreted to cast light on the number and kind of valence bonds formed by the nucleus in question. The principles and assumptions in the theory of Townes and Dailey are reviewed. The conclusions which can be drawn from the data such as a new relation between ionicity and electronegativity, the presence of intermolecular covalent bonding in crystalline iodine, the completely ionic nature of the gaseous alkali halides, etc., are discussed. A.

539.132 : 541.5

11288. Electron distribution in molecules. II. Proton and fluorine magnetic resonance shifts in the halomethanes. L. H. Meyer and H. S. Gutowsky. *J. phys. Chem.*, **57**, 481–6 (*May*, 1954).

For Pt I, see Abstr. 3699 (1953). Experimental chemical shifts in the proton and fluorine magnetic resonances are reported for the simple halomethanes and the chlorofluoromethanes. An analysis of the shifts and their relation to other electron-dependent parameters, such as bond distance and chlorine quadrupole coupling, demonstrates qualitatively the importance of both ionic and double-bonded electron distributions in these compounds. The electron distributions in the halomethanes are related to the electronic effects of the halogens as substituents in benzene. The proton and fluorine resonances in the fluoromethanes were multiplets, the structure arising from indirect coupling of the nuclear spins by the valence electrons. Fluorine chemical shifts were measured in a number of substituted fluorobenzenes, including the *o*-, *m*- and *p*-benzaldehydes, benzyl and benzal chlorides; the corresponding Hammett σ-values, estimated from the chemical shifts, are given. A.

539.132 : 541.5

11289. Electron distribution in molecules. III. The proton magnetic spectra of simple organic groups. L. H. Meyer, A. Saika and H. S. Gutowsky. *J. Amer. Chem. Soc.*, **75**, 4567–73 (*Sept.* 20, 1953).

Complex proton magnetic resonance spectra have been observed with a high-resolution r.f. spectrometer in a large number of simple organic liquids. The components of the resonance absorption have characteristic positions which depend upon the electronic environment of the protons. The "chemical shifts" observed in the resonance positions of the various proton-containing groups are generally in good qualitative accord with the accepted concepts describing the electronic structures of the molecules. A graphical summary is given of the spectra, which appear to be of promise in structural and qualitative analysis, although there are limiting and complicating factors. A.

539.132 : 541.5

11290. Electron distribution in molecules. IV. Phosphorus magnetic resonance shifts. H. S. Gutowsky and D. W. McCall. *J. chem. Phys.*, **22**, 162–4 (*Feb.*, 1954).

Chemical shifts in the phosphorus nuclear magnetic resonance absorption have been measured in twenty compounds. The shifts arise from differences in the magnetic shielding of the phosphorus nuclei by electrons, and the values observed are interpreted qualitatively in terms of the molecular electronic structures. The range in shifts is 7×10^{-4} which is somewhat larger than observed for fluorine on which more extensive data are available. The phosphorus resonance shifts fall into two distinct groups one of which contains compounds with trivalent phosphorus and the other, pentavalent. The shifts in pentavalent compounds fall in a relatively narrow range, generally with greater nuclear magnetic shielding than in the trivalent. The resonance shifts between similar or homologous compounds can be accounted for by considering changes in the importance of ionic and double-bonded electronic structures. A.

539.132

11291. A free-electron theory of conjugated molecules. I. Polycyclic hydrocarbons. J. S. Griffith. *Trans Faraday Soc.*, **49**, 345–51 (*April*, 1953).

A free-electron theory of the mobile electrons of cata-condensed hydrocarbons is proposed. Two conditions are imposed on the form of the wave-function at those carbon atoms which have three near neighbours. One expresses the continuity of the wave-function and the other the Hermitian property of the Hamiltonian. The theory is used to predict spectral transitions for naphthalene and azulene, and to calculate the charge distribution around the naphthalene rings. A.

539.132

11292. A free-electron theory of conjugated molecules. II. A derived algebraic scheme. J. S. Griffith. *Proc. Cambridge Phil. Soc.*, **49**, *Pt* 4, 650–8 (1953).

The values of a free-electron eigenfunction at the carbon nuclei of a conjugated hydrocarbon are found to satisfy a system of algebraic equations. These equations are similar in form to those obtained in the method known as the linear combination of atomic orbitals but only coincide with them for linear polyenes and benzene. The symmetry, degeneracy and energy of the eigenvectors of these free-electron equations correspond exactly to those of the free-electron wave-functions found by the usual methods. From this correspondence, a theorem is deduced about the free-electron charge density in alternant hydrocarbons. A.

539.132

11293. The electronic orbitals, shapes, and spectra of polyatomic molecules. I. AH_2 molecules. A. D. Walsh. *J. Chem. Soc.*, **1953**, 2260–6 (*Aug.*).

The electronic orbitals possible for an AH_2 molecule when linear are correlated with those possible for the molecule when non-linear. Qualitative curves of binding energy *v.* $\angle$HAH are given for the various orbitals. These curves are then used to explain and predict (i) the shapes and (ii) the electronic spectra and associated characteristics of AH_2 molecules. AH_2 molecules containing 4 valency electrons should be linear in their ground states. AH_2 molecules containing 5–8 valency electrons should be bent in their ground states. A.

539.132

11294. The electronic orbitals, shapes, and spectra of polyatomic molecules. II. Non-hydride AB_2 and BAC molecules. A. D. Walsh. *J. Chem. Soc.*, **1953**, 2266–88 (*Aug.*).

A correlation diagram is plotted for the orbitals of linear and non-linear triatomic molecules. Simple reasons are given why particular orbitals become more or less tightly bound as the apex angle changes. The diagram is used to interpret and predict the shapes, reactivities and spectra of non-hydride triatomic molecules. As regards the shapes, the following facts (most of which have been recognized for some time) become understandable: that molecules with not more than 16 valency electrons are linear in their ground states; that molecules with 17, 18, 19 or 20 valency electrons are bent in their ground states, the apex angle decreasing markedly from 16- to 17- and from 17- to 18-electron molecules and less markedly from 18- to 19- and from 19- to 20-electron molecules; and that 22-electron molecules are linear or nearly linear in their ground states. The paper has much in common with an earlier paper by Mulliken [*Rev. Mod. Phys.*, **14**, 204 (1942)]. A.

539.132

11295. The electronic orbitals, shapes, and spectra of polyatomic molecules. III. HAB and HAAH molecules. A. D. Walsh. *J. Chem. Soc.*, **1953**, 2288–96 (*Aug.*).

The electronic orbitals possible for bent and linear HAB and HAAH molecules are correlated. Whether or not a given orbital becomes more or less weakly bound as the molecule is changed from the bent to the linear form is discussed. The results are used to interpret the shapes and spectra of HAB and HAAH molecules and radicals. HAB molecules containing 10 or less valency electrons should be linear in their ground states. Molecules with 10–14 electrons should be bent in their ground states. 16-electron HAB molecules should be linear again. HAAH molecules containing 10 valency electrons should be linear in their ground states. Those containing 12 electrons should be bent but planar (*cis-* and *trans*-forms). Those containing 14 electrons should be bent and non-planar. The spectra of the isoelectronic molecules HCN and C_2H_2 are particularly discussed; the first excited state of each should be non-linear. A.

539.132

11296. The electronic orbitals, shapes, and spectra of polyatomic molecules. IV. Tetratomic hydride molecules, AH_3. A. D. WALSH. *J. Chem. Soc.*, **1953**, 2296–301 (*Aug.*).

The orbitals of planar and pyramidal AH_3 molecules are correlated. A figure is plotted to indicate whether a given orbital rises or falls in energy as the HAH angle is increased. This is used to explain and predict (i) the shapes and (ii) the spectra of AH_3 molecules. In their ground states, AH_3 molecules containing not more than 6 valency electrons should be planar, and molecules containing 7 or 8 should be pyramidal. A.

539.132

11297. The electronic orbitals, shapes, and spectra of polyatomic molecules. V. Tetratomic, non-hydride molecules, AB_3. A. D. WALSH. *J. Chem. Soc.*, **1953**, 2301–6 (*Aug.*).

The procedure developed in previous papers of this series is applied to tetratomic, non-hydride molecules, AB_3. A correlation diagram is plotted between the orbitals possible for planar AB_3 molecules and those possible for pyramidal molecules. This enables a discussion to be given of the shapes of such molecules, and comments to be made on their reactivities and spectra. AB_3 molecules containing $\not>24$ valency electrons are planar in their ground states. Molecules containing 25 or 26 valency electrons should be pyramidal in their ground states, the BAB angle decreasing with increase in the number of electrons. Molecules containing 24 valency electrons should be pyramidal in their first excited states. The ground states of molecules containing 28 valency electrons should be planar or nearly planar. A.

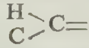
539.132

11298. The electronic orbitals, shapes, and spectra of polyatomic molecules. VI. H_2AB molecules. A. D. WALSH. *J. Chem. Soc.*, **1953**, 2306–17 (*Aug.*).

The correlation diagram between the orbitals possible for planar and non-planar H_2AB molecules is obtained as a special case of the diagram given in Pt V for AB_3 molecules. The diagram is used to interpret the shapes of H_2AB molecules and especially to discuss the near ultraviolet spectrum of formaldehyde. It is shown that the first excited state of formaldehyde should be non-planar, though possibly only slightly so. Confirmatory evidence is found in the fluorescence spectrum. Various interpretations of the near ultraviolet spectrum are discussed, without it being possible to reach a final decision. There are, however, strong arguments for the occurrence of ν_5 in the spectrum; occurrence of this may be regarded as due to the O atom in the upper state lying very slightly out of the mirror plane which bisects the HCH angle. A.

539.132

11299. The electronic orbitals, shapes, and spectra of polyatomic molecules. VII. A note on the near-ultraviolet spectrum of acetaldehyde. A. D. WALSH. *J. Chem. Soc.*, **1953**, 2318–20 (*Aug.*).

The near-ultraviolet spectrum of acetaldehyde, like that of formaldehyde, consists of at least two electronic transitions. This makes analysis difficult, but the following definite points emerge. Ground-state fundamental frequencies of ~ 630 and $779\ \mathrm{cm}^{-1}$ suggested by Thompson and Harris are confirmed. A further probable ground-state fundamental frequency is $\sim 475\ \mathrm{cm}^{-1}$. The long-wavelength end of the spectrum involves an excited state frequency of $\sim 320\ \mathrm{cm}^{-1}$ which plausibly represents an out-of-plane bending of the  $^{H}_{C}{>}C{=}O$ group. The first electronic transition of formaldehyde is shifted to short wavelengths by methyl substitution; but the second electronic transition probably to long wavelengths. A.

539.132

11300. The electronic orbitals, shapes, and spectra of polyatomic molecules. VIII. Pentatomic molecules: CH_3I. A. D. WALSH. *J. Chem. Soc.*, **1953**, 2321–4 (*Aug.*).

The electronic orbitals of methyl iodide are discussed with particular reference to the three lowest-energy absorption transitions. It is shown that the first of these plausibly leads to dissociation of the molecule. In the equilibrium forms of the excited states of each of the other two transitions (i) the HCH angle should be markedly reduced and hence the totally symmetrical, CH_3-deformation vibration should appear strongly, (ii) the C–I bond should be lengthened a little and hence the C–I valence vibration should appear, probably less strongly, and (iii) the I atom should lie off the trigonal axis of symmetry of the CH_3 group and hence the ν_6e deformation vibration should appear and certain consequences be apparent in the fine structure of the bands. The observed spectrum confirms all these expectations. A.

539.132

11301. The electronic orbitals, shapes, and spectra of polyatomic molecules. IX. Hexatomic molecules: ethylene. A. D. WALSH. *J. Chem. Soc.*, **1953**, 2325–9 (*Aug.*).

The electronic orbitals of the ethylene molecule are described. It is concluded that the first, triplet or singlet, excited state of the molecule should have (i) a pyramidal arrangement of the bonds about each C atom, (ii) one CH_2 group twisted relative to the other through 90° about the C–C bond, and (iii) each C atom possibly slightly out of the mirror plane that bisects the HCH angle of the other CH_2 group. The first excited state of a molecule containing n electrons should belong to the same symmetry class as the ground state of a similar molecule containing $n+1$ or $n+2$ electrons. The symmetry of the ground state of the N_2H_4 molecule affords strong support for conclusions (i) and (ii) concerning the first excited state of the C_2H_4 molecule. A.

539.132

11302. The electronic orbitals, shapes, and spectra of polyatomic molecules. X. A note on the spectrum of benzene. A. D. WALSH. *J. Chem. Soc.*, **1953**, 2330–1 (*Aug.*).

The reasons are discussed for the appearance of numerous non-totally symmetrical vibration frequencies in the near-ultraviolet spectrum of benzene. On the basis of conclusions reached in Pt IX and on the assumption that changes of restoring forces in the first excited states of benzene relatively to the ground state are similar to those in the first excited state of ethylene relatively to its ground state, a large number of such vibrational modes might be expected in the benzene spectrum. A.

539.132

11303. The structure of carbon monoxide. R. C. Sahni. *Trans Faraday Soc.*, **49**, 1246–53 (*Nov.*, 1953).

The electronic structure of carbon monoxide is discussed in terms of molecular orbitals and in terms of localized orbitals in order to illustrate the properties of these orbitals for an unsymmetrical molecule. The electronic distribution in the CO molecule is compared with that of the CO group in the carbon dioxide molecule. A.

539.132

11304. Properties of certain partial derivatives of secular equations. I. Samuel. *C.R. Acad. Sci.* [*Paris*] **238,** 2422–4 (*June* 21, 1954) *In French.*

If the secular equation of a molecule is $F(Y_i, \ldots Y_n) = 0$, Y_i being the diagonal elements, then $\partial F/\partial Y_i = 0$ is the secular equation of the molecule obtained by removing atom *i*, or any symmetrically equivalent atom. Various other relations follow; e.g. if Y_i is replaced by $Y_i + \alpha$, the secular equation becomes $F + \alpha\partial F/\partial Y_i = 0$. J. HAWGOOD

539.132

11305. Free radicals by mass spectrometry. VI. The bond dissociation energies of some methyl, allyl, and benzyl compounds by electron impact. F. P. Lossing, K. U. Ingold and I. H. S. Henderson. *J. chem. Phys.*, **22,** 1489–92 (*Sept.*, 1954).

For Pt V, see Abstr. 5845 (1954). The appearance potentials for the radical ions from methyl, allyl and benzyl halides and two other derivatives have been measured. Using previously measured values for the ionization potentials of the free radicals, the R–X bond dissociation energies in these compounds have been calculated. The results are in good agreement with published data for the methyl and allyl compounds, and in fair agreement for the benzyl halides. A.

539.132

11306. Resonance energies and charge distributions of unsaturated hydrocarbon radicals and ions. A. Brickstock and J. A. Pople. *Trans Faraday Soc.*, **50,** *Pt* 9, 901–11 (*Sept.*, 1954).

A self-consistent molecular-orbital treatment, including electron interaction, is used to discuss resonance energies and charge distributions of certain conjugated hydrocarbon radicals and ions. The principal aim is to test the validity of conclusions reached on the basis of the simpler Hückel molecular-orbital theory, using an effective one-electron Hamiltonian. The following general conclusions are reached for alternant systems. (i) The resonance energy of a conjugated ion (positive or negative) should be greater than that of the corresponding radical. (They are equal according to the Hückel theory.) (ii) The distribution of charge in conjugated ions may differ considerably from that predicted by the Hückel theory, there being a tendency for electrons of cations to keep to the central parts of the system. A.

539.132 : 535.343

11307. The electronic spectra of aromatic molecules. I. Benzenoid hydrocarbons. M. J. S. Dewar and H. C. Longuet-Higgins. *Proc. Phys. Soc.* [*London*] *A*, **67,** 795–804 (*Sept.*, 1954).

Certain regularities observed in the spectra of benzenoid hydrocarbons by Clar and by Klevens and Platt are interpreted in terms of the LCAO molecular orbital theory on the assumption that electron repulsion mixes together only configurations which are degenerate when overlap is neglected. The frequency and intensity relationships between Clar's α, p, β and β' bands find a simple interpretation in this scheme, and the near ultraviolet spectra of benzene, naphthalene and anthracene are interpreted in the light of this theory. A.

539.132 : 539.133

11308. The structure of some simple molecules with lone pair electrons. A. B. F. Duncan and J. A. Pople. *Trans Faraday Soc.*, **49,** 217–24 (*March*, 1953).

Deals with the distribution of lone pair electrons in the isoelectronic series NH_3, H_2O and HF. Calculations based on the molecular orbital theory indicate that lone pair electrons make a substantial contribution to the dipole moments of these molecules. Making use of the observed total dipole moments, it is possible to obtain approximate analytical forms for all the orbitals and then to make certain qualitative deductions about the electron density. The theory is also used to estimate electric quadrupole moments for these molecules. A.

539.132 : 539.133

11309. Electron migration and dipole moment of molecules. K. Nukasawa. *Monogr. Res. Inst. Appl. Elect. Hokkaido Univ.*, *No.* 4, 41–59 (1954).

An LCAO perturbation method similar to that of Dewar [Abstr. 3701 (1953)] is used to discuss the change in dipole moment caused by substitution of non-polar radicals in organic molecules. The molecule is treated as two parts whose MO's are given by empirical data, and the interaction between them treated by 2nd-order perturbation theory, neglecting all but nearest-neighbour interactions. Approximate calculations on molecules formed by condensation of pairs of: ethylene, formaldehyde, methane, benzene, butadiene, give reasonable agreement with experiment. The effect of antisymmetrization is discussed. J. HAWGOOD

539.132

11310. The branching condition in the electron-gas method. H. Kuhn. *Z. Elektrochem.*, **58,** *No.* 4, 219–25 (1954) *In German.*

Summarizes the author's assumption made to explain the light absorption of organic dyes, viz. that π-electrons behave like unidimensional stationary waves which satisfy certain boundary conditions (in particular the branching condition in molecules with the branched electron gas). The branching equation as modified by Griffith (1953) is accepted. Analyses in more detail the relationship between the amplitude of the model unidimensional electron wave and the probability of the electron's being in the field of action of the atom; the latter is approximately proportional to the square of the former, even when the atom in question is in the branching position.

F. LACHMAN

539.132

11311. On the temperature dependence of the molecular polarization of ammonia. M. Katayama. *J. chem. Phys.*, **22**, 1473–6 (*Sept.*, 1954).

The molecular polarization of ammonia is calculated quantum mechanically by taking account of the dipole matrix elements of inversion doubling in the first excited state as well as in the ground state of the symmetric deformation vibration. It is found to be reasonable that the dipole moment of this molecule decreases at higher temperatures. The atomic polarization is also calculated and the result, $P_A = 0{\cdot}65$ cc, is in good agreement with the observed value. A.

539.133 : 537.226.33

The influence of molecular shape upon dielectric relaxation times. *See Abstr.* 11034

539.133 : 537.226.33 : 532.13

Dielectric relaxation, viscosity and molecular shape. *See Abstr.* 10840

539.133 : 535.343.4–14

Molecular microwave spectra tables. *See Abstr.* 10955

539.133

11312. The structure of trifluorosilane from microwave spectra. G. A. Heath, L. F. Thomas and J. Sheridan. *Trans Faraday Soc.*, **50**, 779–83 (*Aug.*, 1954).

Frequency measurements on pure rotational transitions of trifluorosilane are extended to the $J = 1 \rightarrow 2$, $2 \rightarrow 3$ and $3 \rightarrow 4$ transitions of F_3SiD and the $J = 2 \rightarrow 3$ and $4 \rightarrow 5$ transitions of F_3SiH. Values of B_0 computed are: for $F_3^{28}SiD$, $6890{\cdot}08 \pm 0{\cdot}05$ Mc/s; for $F_3^{29}SiD$, $6880{\cdot}15 \pm 0{\cdot}08$ Mc/s and for $F_3^{30}SiD$, $6870{\cdot}53 \pm 0{\cdot}1$ Mc/s. The distortion coefficients D_J for $F_3^{28}SiH$ and $F_3^{28}SiD$ are approximately 5 kc/s and 4 kc/s respectively. From considerations of various combinations of data for isotopically substituted molecules, zero-point energy effects being neglected, the molecular dimensions calculated are: $d_{\text{SiH}} = 1{\cdot}455 \pm 0{\cdot}01$ Å, $d_{\text{SiF}} = 1{\cdot}565 \pm 0{\cdot}005$ Å and $\angle \text{FSiF} = 108° \ 17' \pm 30'$. The influence of zero-point energy effects on the parameters d_{SiH} and d_{SiD} is considered briefly. A.

539.133 : 539.27

11313. An electron diffraction investigation of the molecular structures of some silicon compounds. C. J. Wilkins and L. E. Sutton. *Trans Faraday Soc.*, **50**, 783–96 (*Aug.*, 1954).

From an electron diffraction examination of the free molecules, interatomic distances have been obtained in trimethylfluorosilane [$(CH_3)_3SiF$], dimethylchlorofluorosilane [$(CH_3)_2SiClF$], and trichlorosilanethiol (Cl_3SiSH). The length of the Si–F link in the first of these ($1{\cdot}57 \pm 0{\cdot}02$ Å) is slightly greater than the values found in compounds containing more than one fluorine attached to silicon. The length in the second of the three compounds ($1{\cdot}60 \pm 0{\cdot}02$ Å) may be still greater; but the difference has not been definitely established. Both values are much less than the sum of either old or new covalent radii. The Si–C bond lengths are the same, $1{\cdot}89 \pm 0{\cdot}02$ Å, and are both somewhat less than the sum of the covalent radii. The Si–Cl bond length found is $2{\cdot}03 \pm 0{\cdot}03$ Å in the second compound and $2{\cdot}02 \pm 0{\cdot}02$ Å in the third: the Si–S bond length is $2{\cdot}14 \pm 0{\cdot}02$ Å. All these values are less than the sums of covalent radii. The possible cause of these contractions in bond length is discussed in the light of previous hypotheses. The observations prove to be explainable as either direct or indirect effects of polar character in the σ-bonds; and although in general the latter cause provides the more satisfactory hypothesis, it is possible that both contribute to produce anomalies of bond length. A.

539.133 : 535.343–14

Microwave spectrum and structure of benzonitrile. *See Abstr.* 10947

ATOMIC STRUCTURE . NUCLEUS ISOTOPES 539.15

539.152.1

11314. On the electrostatic energy of atomic nuclei. J. Palacios. *Rev. Fac. Ciênc. Univ. Lisboa B*, **1**, 139–48 (1951) *In Spanish.*

The expression of the electrostatic energy of a nucleus of radius R, given by Bethe and Bacher, needs a small correction due to the fact that the protons do not have the same radius as the final nucleus. The correct formula is:

$$W = 3e^2/5(Z^2/R - Z/r_0),$$

where r_0 is the radius of the proton. With this correction, the formula gives a better agreement between the values of r_0 obtained with the mass differences of mirror nucleids, the average value being $r_0 = 1{\cdot}32 \times 10^{-13}$ cm. As a consequence of this correction, the semi-empirical mass formula becomes:

$$M = (M_n + a_1)A - (M_n - M_p + \varepsilon)Z + a_2A^{2/3} + a_3(A/2 - Z)^2/A + \varepsilon Z^2/A^{1/3} + \delta(A, Z)$$

and the empirical coefficients a_1, a_2 and a_3 must be changed accordingly. A.

539.152.1

11315. Critical potentials and virtual levels of atomic nuclei. J. Humblet. *Bull. Soc. Roy. Sci. Liège*, **23**, 148–63 (*May*, 1954) *In French.*

Some extensions of Abstr. 5975 (1952) dealing with angular moment > 0, in which case the condition for a virtual level may have a double root. The effect of a perturbation in removing the degeneracy is studied. Expressions for the scattering cross-section analogous to the Breit–Wigner and Bethe–Peierls formulae are derived.

W. J. SWIATECKI

539.152.1

11316. Short range forces and nuclear energy levels in the neighbourhood of ^{208}Pb. D. M. Brink. *Proc. Phys. Soc.* [*London*] *A*, **67**, 757–72 (*Sept.*, 1954).

The lowest excited states of nuclei differing by two particles from the double closed shell of Pb^{208} can be classified in terms of two-particle configurations. For a two-particle configuration, this paper gives an expansion for the matrix elements of a short-range central interaction potential of any exchange type, as a power series in the range of the potential. It is shown that, in any configuration and with forces of range consistent with low energy proton neutron scattering data, the zero range approximation for the matrix elements is good for Wigner or Bartlett forces. For Majorana and Heisenberg forces the zero range approximation is fair for states of highest spin, but is inadequate for the states of lowest spin. Calculations, applied to Bi^{210} (RaE) indicate that the β-decaying state of this nucleus has spin 0, 1 or possibly 2 and odd parity. A.

539.152.1

11317. Approximate nuclear density distributions in light elements. K. M. GATHA, G. Z. SHAH AND N. J. PATEL. *Proc. Phys. Soc.* [*London*] *A*, **67**, 773–9 (*Sept.*, 1954).

With a suitable transformation of parameters, it is found that the experimental angular distributions for the nuclear scattering of 340 MeV nucleons by light elements can be reasonably represented by a characteristic angular distribution. Within the region of validity of the first Born approximation, the radial distribution method has been used to determine the corresponding characteristic nuclear density distribution for light elements. A.

539.152.1

11318. Energy levels in Pb^{206} from the decay of Bi^{206}. D. E. ALBURGER AND M. H. L. PRYCE. *Phys. Rev.*, **95**, 1482–99 (*Sept.* 15, 1954).

The energies, spins and parities of 10 excited states in Pb^{206} and the probable energies, spins and parities of two additional states have been established by studies of 6·4-day Bi^{206} decay. The experiments include intensity and precision energy measurements on the conversion lines in a double-focusing spectrometer; coincidences between pairs of *K*-conversion lines in a two-lens "spectrogoniometer"; coincidences between γ-rays and conversion electrons in a modified intermediate-image spectrometer; discovery of a 145 ± 15 microsecond isomeric state decaying by either of two *E*3 transitions; examination of the low-energy conversion spectrum; and relative γ intensity measurements with a scintillation spectrometer. The adopted decay scheme contains 28 of the observed transitions and satisfies all of the conditions imposed by the energy and coincidence measurements. A few additional very weak transitions are unassigned. It is shown from a theoretical analysis based on the shell model that the observed levels are in agreement with the approximate calculations. Eleven γ-rays decaying with a half-life of 14 days are assigned to Bi^{205}. A.

539.152.1 : 539.172.4

11319. The neutron–proton system with a central exponential potential. I. P.-O. BRUNDELL AND B. ENANDER. *K. Tekn. Högsk. Handl. No.* 60, 12 *pp.* (1952).

The interaction between a neutron and a proton in the ^3S- and ^1S-state is assumed to be described by a central potential of the form: $B \times e^{-\lambda r}$. It is further assumed that the range of the potential, $1/\lambda$, is the same in these two states, but that the depth, B, is different: B_t and B_s. Exact expressions for the deuteron binding energy, $|E_0|$, the epithermal scattering cross-section, σ_0, and the coherent scattering amplitude, f, have been derived. For two combinations of the parameters B_t, B_s and λ the theoretical and experimental values of $|E_0|$, σ_0 and f agree. Calculations of the effective range, r_0, of the potential have shown that one of these is physically unacceptable as it gives a too large r_0. Choosing the other system of parameters the scattering cross-section has been calculated by means of the effective range method in the energy region, where the contribution from the *P*-states can be neglected (up to 5 MeV). The results agree with recent measurements within the experimental errors. Finally the capture cross-section has been computed. A.

539.152.2

11320. Nuclear spin and hyperfine structure interaction of the 3·1 hr Cs^{134} isomer. V. W. COHEN AND D. A. GILBERT. Letter in *Phys. Rev.*, **95**, 569 (*July* 15, 1954).

The observation of 8 atomic beam magnetic resonances leads to a spin 8 and magn. moment $\mu = 1 \cdot 10 \pm 0 \cdot 01$ n.m. for Cs^{134*}. Theoretical interpretation suggests a mixture of 53% $(g_{7/2}, h_{11/2})$ and 47% $(d_{5/2}, h_{11/2})$ proton–neutron configurations, and pos. sign for μ. See also abstract following and Abstr. 11358 (1954). W. J. SWIATECKI

539.152.2

11321. Nuclear spin and magnetic moment of 3·1 hr Cs^{134m}. L. S. GOODMAN AND S. WEXLER. Letter in *Phys. Rev.*, **95**, 570 (*July* 15, 1954).

An experiment similar to that of the preceding abstract gave spin 8 and $\mu = 1 \cdot 10$ n.m. W. J. SWIATECKI

539.152.2

11322. Magnetic resonance spectra of beryl crystals. L. C. BROWN AND D. WILLIAMS. Letter in *Phys. Rev.*, **95**, 1110 (*Aug.* 15, 1954).

Nuclear resonance patterns are observed and interpreted in terms of Be^9 $I = 3/2$, $\nu_0 = 4 \cdot 6674 \pm 0 \cdot 0005$ Mc/s at 7800 gauss; Al^{27} $I = 5/2$, $\mu = 3 \cdot 6401 \pm 0 \cdot 003$ n.m. and $e^2qQ/h = 3 \cdot 070 \pm 0 \cdot 015$ Mc/s. D. H. WHIFFEN

539.152.2

11323. Moments of Na^{23}. M. F. SCHARFF. Letter in *Phys. Rev.*, **95**, 1114 (*Aug.* 15, 1954).

Using matrix methods to solve 28 linear equations it is shown that the configuration $[(d_{5/2})^3_P(d_{5/2})^4_N]_{I=3/2}$ can give agreement with the experimental values of magnetic and quadrupole moments ($\mu = 2 \cdot 217$ n.m, $Q = +0 \cdot 01 \pm 0 \cdot 06 \times 10^{-24}$ cm^2). W. J. SWIATECKI

539.152.2

11324. Regularity in magnetic moments of odd nuclei. M. F. SCHARFF. Letter in *Phys. Rev.*, **95**, 1112–13 (*Aug.* 15, 1954).

The rule "the addition of an α-particle to an odd nucleus pushes its magnetic moment toward (or away from) the Schmidt line if the spin of the heavier nucleus is $I = l - \frac{1}{2}$ (or $l + \frac{1}{2}$), where l is the shell-model value for the last odd nucleon," is obeyed in 41 out of 49 listed cases. [Cf. Abstr. 1975 (1951).] W. J. SWIATECKI

539.152.2

11325. The deviations of nuclear magnetic moments from the Schmidt lines. R. J. BLIN-STOYLE AND M. A. PERKS. *Proc. Phys. Soc.* [*London*] *A*, **67**, 885–94 (*Oct.*, 1954).

It is shown that the deviations of nuclear magnetic moments from the Schmidt lines can be accounted for in terms of simple interconfigurational mixing. In particular it has been found possible to explain the large deviation of Bi^{209}. A.

539.152.2

11326. Some experiments and theoretical considerations on the electric h.f.s. method of nuclear alignment. J. M. Daniels. *Canad. J. Phys.*, **32,** 662–73 (*Oct.*, 1954).

An account is given of two unsuccessful experiments to detect a nuclear electric quadrupole splitting in a solid by essentially thermal methods. In one experiment *p*-diiodobenzene was mixed with potassium chromium alum and cooled to 0·01°K by adiabatic demagnetization, in an attempt to find the nuclear specific heat of the iodine. In another experiment, a single crystal of cobalt *p*-toluene-sulphonate containing some I^{131} as *p*-iodobenzenesulphonate was cooled by adiabatic demagnetization, in an attempt to produce an alignment of the I^{131} nuclei and hence an anisotropic distribution of the emitted γ-rays. This is followed by a theory of the relaxation time for the transfer of heat from an assembly of nuclei with a quadrupole splitting to an assembly of paramagnetic ions in the same crystal. The behaviour of the relaxation time is discussed with regard to variations of external magnetic field, and replacement of the nuclei or the paramagnetic ions with inert entities. A numerical estimate is made of the relaxation time of cobalt/zinc *p*-bromobenzenesulphonate for cobalt concentrations of 100% and 1%. The result of the two experiments is discussed in relation to the theory. An extension of the Casimir and du Pré relations to cover this case is given. A.

539.152.2 : 530.162

11327. Statistical mechanics and the Overhauser nuclear polarization effect. C. Kittel. Letter in *Phys. Rev.*, **95,** 589–90 (*July* 15, 1954).

The connection of the results of Overhauser [Abstr. 1565 (1954)] with the general principles of statistical mechanics is pointed out. The discussion is generalized to treat polarization of a nuclear spin system which suffers spin-lattice relaxation by dipolar or hyperfine interaction with a saturated electron spin system. W. J. SWIATECKI

539.152.2 : 538.222

11328. Nuclear spin of 241 Pu. B. Bleaney, P. M. Llewellyn, M. H. L. Pryce and G. R. Hall. Letter in *Phil. Mag.*, **45,** 991–2 (*Sept.*, 1954).

Paramagnetic electron resonance on a single crystal of $(UO_2)Rb(NO_3)_3$ with 40 μg of Pu is observed and indicates Pu^{239} $I = 1/2$, $\mu = 0{\cdot}4 \pm 0{\cdot}2$ n.m.; Pu^{241} $I = 5/2$, $\mu = 1{\cdot}4 \pm 0{\cdot}6$ n.m. and $\mu(241)/\mu(239) = 3{\cdot}53 \pm 0{\cdot}02$ n.m. D. H. WHIFFEN

539.152.2 : 538.222

11329. Paramagnetic resonance in neptunyl rubidium nitrate. B. Bleaney, P. M. Llewellyn, M. H. L. Pryce and G. R. Hall. Letter in *Phil. Mag.*, **45,** 992–3 (*Sept.*, 1954).

Paramagnetic electron resonance of $(UO_2)Rb(NO_3)_3$ with 400 μg of Np^{237} confirms spin $\frac{5}{2}$ and gives $\mu = 6 \pm 2{\cdot}5$ n.m. for this nucleus. D. H. WHIFFEN

539.152.2 : 539.11

11330. Indirect exchange coupling of nuclear magnetic moments by conduction electrons. M. A. Ruderman and C. Kittel. *Phys. Rev.*, **96,** 99–102 (*Oct.* 1, 1954).

A calculation is given of the indirect exchange $\mathbf{I}_i.\mathbf{I}_j$ type coupling of nuclear magnetic moments in a metal by means of the hyperfine interaction with the conduction electrons. The interaction appears to account qualitatively for the broad nuclear spin resonance lines observed in natural metallic silver. It is expected that the interaction may sharpen the resonances in pure isotopic specimens. The line shape of the minority isotope in a binary mixture may tend to be Gaussian, while that of the majority isotope may tend to be Lorentzian, if the indirect exchange interaction is dominant. A.

539.152.2 : 539.132

11331. Nuclear magnetic resonance in solid hydrogen with various *ortho*-concentrations. T. Sugawara, Y. Masuda, T. Kanda and E. Kanda. Letter in *Phys. Rev.*, **95,** 1355–6 (*Sept.* 1, 1954).

539.152.2 : 539.132

11332. Magnetic resonance absorption of diphenyl-picryl hydrazyl at low magnetic fields. M. A. Garstens, L. S. Singer and A. H. Ryan. *Phys. Rev.*, **96,** 53–6 (*Oct.* 1, 1954).

Measurements of the magnetic resonance absorption line shapes and *g* factors of diphenyl-picryl hydrazyl have been made at several frequencies below 15 Mc/s using a linearly polarized r.f. field. An approximately inverse fourth-power dependence of the *g* factor with frequency was found. The frequency dependence of both the *g* factor and line shape are found to be in agreement with a theory for the low-field case developed in a previous paper. A.

539.152.2 : 539.181

11333. Spins and hyperfine splittings of Ag^{111} and Cu^{64}. A. Lemonick and F. M. Pipkin. Letter in *Phys. Rev.*, **95,** 1356–7 (*Sept.* 1, 1954).

A magnetic resonance experiment with focused atomic beams and a Geiger counter detector for radioactive nuclei gives Cu^{64} $I = 1$, hyperfine, splitting 1278 ± 20 Mc/s and $|\mu| = 0{\cdot}40 \pm 0{\cdot}05$ n.m. For Ag^{111} $I = \frac{1}{2}$, the splitting is 2180 ± 100 Mc/s and $|\mu| = 0{\cdot}144 \pm 0{\cdot}007$ n.m. D. H. WHIFFEN

539.153

11334. On the theory of atomic collisions accompanied with the charge transfer. K. Takayanagi. *Sci. Rep. Saitama Univ. A*, **1,** *No.* 1, 9–22 (1952).

Some preliminary investigations on charge transfer processes between the positive atomic ion and the neutral atom by various methods of approximation, such as Born's approximation and the semi-classical one in which the nuclear motion is treated by a classical parameter. Brief discussions are also given for the strong coupling approximation, the method of wave packets, etc. Throughout the discussions special attention is paid to the intermediate velocity region where the relative velocity of the two atoms is of order comparable with the orbital electron velocity. The results of calculation show more or less good qualitative agreement with the general tendency of the experimental data so far obtained, though the accuracy of the calculations is not yet sufficient to examine these problems quantitatively. A.

539.153

11335. Application of the many-configuration approximation for determining the dipole force in beryllium-type and boron-type atoms. A. B. Bolotin and A. P. Yutsis. *Zh. éksper. teor. Fiz.*, **24**, *No.* 5, 537–44 (1953) *In Russian.*

Presents formulae for the total dipole force for the $1s^22s2p$–$1s^22s^2$ transitions in the Be-type and $1s^22s2p^2$–$1s^22s^22p$ transitions in the B-type atoms, both in two-configuration approximation. Constants of the analytical single-electron wave-functions are determined for B, C^+, N^{2+}, O^{3+} and F^{4+} atoms in $1s^22p^3$ and $1s^22s2p^2$ configurations; these functions have been used to determine the values of the total dipole force, oscillator force, and probability of transition for transitions $1s^22s2p$–$1s^22s^2$ in atoms Be, B^+, C^{2+}, N^{3+} and O^{4+}, and for transitions $1s^22s2p^2$–$1s^22s^22p$ in atoms B, C^+, N^{2+}, O^{3+} and F^{4+}. The total dipole force obtained by means of the many-configuration approximation is $1/1 \cdot 7$–$1/1 \cdot 5$ times that obtained by means of the single-configuration approximation (for the ^2S–^2P transition in B-type atoms, the former is $1 \cdot 5$–$1 \cdot 7$ times greater than the latter). F. LACHMAN

539.153

11336. Remarks on the calculation of the polarizability of atomic 2*s* orbitals. J. Guy, M. Harrand and J. Tillieu. *Ann. Phys.* [*Paris*] **9**, 373–81 (*July–Aug.*, 1954) *In French.*

Different forms are taken for $g(r)$ inside and outside the nodal surface $r = r_n$ of ψ_{2s}, where $\psi = \psi_{2s} [1 + Fg(r) \cos \theta]$, F being the applied field. It is shown that for H, the inner part contributes very little to the polarizability, and calculations are made for H, Li and Be 2*s* orbitals by a variation method, treating only $r > r_n$, with $g(r)$ a power series in $r - r_n$, and a rapid approach to the exact solution is made as more parameters are used, two or three parameters being sufficient for good agreement. J. HAWGOOD

539.153

11337. The self-consistent field for Au^+. W. G. Henry. *Proc. Phys. Soc.* [*London*] *A*, **67**, 789–94 (*Sept.*, 1954).

The results are presented of the calculation of the self-consistent field, without exchange, for Au^+. A.

539.153

11338. Electron spin magnetic moment in atomic hydrogen. R. Beringer and M. A. Heald. *Phys. Rev.*, **95**, 1474–81 (*Sept.* 15, 1954).

The ratio of the electron-spin g factor to the proton g factor has been measured in atomic hydrogen by a precision microwave magnetic resonance absorption technique. The result obtained is $-g_s/g_p = 658 \cdot 2277 \pm 0 \cdot 0002$, where g_p refers to protons in molecular hydrogen. The ratio is in good agreement with the atomic-beam result of Koenig, Prodell and Kusch, and verifies their conclusions concerning the magnitude of the quantum electrodynamical contribution to g_s. A.

539.153 : 537.561

11339. The photo-ionization cross section of lithium. A. L. Stewart. *Proc. Phys. Soc.* [*London*] *A*, **67**, 917–21 (*Oct.*, 1954).

The photo-ionization cross-section of lithium is calculated using Hartree–Fock wave-functions. Good agreement is obtained between the dipole length and dipole velocity formulae for the cross-section over the wavelength range considered, 2300 Å–1800 Å. The mean value at the spectral head is found to be $1 \cdot 16 \times 10^{-18}$ cm^2, considerably smaller than either of the previous theoretical estimates by Hargreaves (1929) and by Trumpy (1929). The cross-section curve rises on the short wavelength side of the series limit, as was found by Hargreaves. A.

539.153 : 537.561

11340. The photo-ionization of neon. M. J. Seaton. *Proc. Phys. Soc.* [*London*] *A*, **67**, 927–9 (*Oct.*, 1954).

Previous calculations of the photo-ionization cross-section of neon have been extended to wavelengths just beyond the L_1 edge at 256 Å. The absolute value of the calculated cross-section is found to be in reasonable agreement with the experimental results of Lee and Weissler and of Ditchburn and Marr, but compared with the calculated results the experimental curve rises more steeply just beyond the threshold and falls more rapidly at higher energies. A.

539.153.4

11341. Hyperfine structure of helium-3 in the metastable triplet state. G. Weinreich and V. W. Hughes. *Phys. Rev.*, **95**, 1451–60 (*Sept.* 15, 1954).

The He^3 atom in the $^3S_1$ metastable state represents a system simple enough to be calculable by modern computing methods. For this reason a measurement of the hyperfine splitting of this state is of particular interest, since it is expected that a comparison with theory will reveal some effects of relativity, quantum electrodynamics, and nuclear structure. The measurement reported here was made by the atomic-beam magnetic resonance method. Three cubic centimetres NTP of He^3 gas was continuously circulated and purified in a closed vacuum system. Frequencies of transitions between hyperfine levels were measured in a magnetic field of about $\frac{3}{4}$ gauss, with the final precision limited by inhomogeneity of the magnetic field. The value thus obtained for the (inverted) h.f.s. splitting is $6739 \cdot 71 \pm 0 \cdot 05$ Mc/s. The best theoretical value currently available is $6735 \cdot 9 \pm 4 \cdot 7$ Mc/s, as calculated by Teutsch and Hughes from the six-term Hylleraas function (see abstract following). A more informative comparison with theory awaits the calculation of a more accurate electronic wave-function. A.

539.153.4

11342. Hyperfine structure of helium-3 in the metastable triplet state. W. B. Teutsch and V. W. Hughes. *Phys. Rev.*, **95**, 1461–3 (*Sept.* 15, 1954).

See preceding abstract. The Fermi value of the h.f.s. splitting in this state is computed here using various available wave-functions, including the six-term Hylleraas function of Huang. An error estimate for the h.f.s. calculation can be made from a knowledge of the accuracy of the calculated binding energy. In all cases, the actual discrepancy between the computed value of the h.f.s. and the experimental result is consistent with the estimated inaccuracy. In particular, the Hylleraas function yields a value of the negative binding energy of $0 \cdot 087600 \times 4hcR_{He^4}$ (experimental value $0 \cdot 087618 \times 4hcR_{He^4}$), and hence gives the h.f.s. to about 0·1%. Thus the anomalous magnetic moment of the electron should be taken into account. The calculated result, including the order α anomalous moment of the electron and the order m/M reduced mass correction, is 6735·9 ± 4·7 Mc/s as compared with the experimental value of 6739·71 ± 0·05 Mc/s. Relativistic, higher-order quantum electrodynamic, and nuclear structure effects are somewhat smaller than the uncertainty in the calculation. A.

539.153.4

11343. Improved theory of the Zeeman effect of atomic oxygen. K. Kambe and J. H. Van Vleck. *Phys. Rev.*, **96**, 66–71 (*Oct.* 1, 1954).

The previous calculations of Abragam and Van Vleck on the g factors of the $2p^4\ {}^3P$ terms of atomic oxygen are refined by including exchange, using better wave-functions, and not assuming that the charge distribution in which a $2p$ electron moves is spherically symmetric. A general technique is developed for calculating the relativistic and diamagnetic corrections to the g factors of complex atoms (Breit–Margenau and Lamb terms, etc.) by an expansion in spherical harmonics which is an extension of the well-known Slater procedure for computing the angular dependence of electrostatic energy. The integrals encountered are usually either of the Condon and Shortley F, G type, or variants thereof. The most important members are computed by means of the wave-functions of Hartree, Hartree and Swirles, based on a Fock self-consistent field, but some of the minor contributions are estimated with Slater wave-functions improved by introducing slightly different screening constants for the $2s$ and $2p$ terms. When all corrections are comprised, including also the Schwinger electrodynamic shift, motion of nucleus and deviations from Russell–Saunders coupling, the calculated values of the g factors for the ${}^3P_1$ and ${}^3P_2$ terms are, respectively, 1·500974, 1·500913, in excellent agreement with Rawson and Beringer's experimental determinations 1·500971, 1·500905. A.

539.153.4

11344. Coulomb wave functions in the transition region. M. Abramowitz and H. A. Antosiewicz. *Phys. Rev.*, **96**, 75–7 (*Oct.* 1, 1954).

Expansions, involving the Airy integrals, of the functions $F_L(\eta, \rho)\ G_L(\eta, \rho)$ are obtained from a study of the Coulomb wave equation. These expansions are convergent in the region $|\rho - \rho_1| < \rho_1$, where $\rho_1 = \eta + [\eta^2 + L(L+1)]^{\frac{1}{2}}$. A.

539.153.4

11345. Evaluation of Coulomb wave functions along the transition line. M. Abramowitz and P. Rabinowitz. *Phys. Rev.*, **96**, 77–9 (*Oct.* 1, 1954).

Asymptotic representations are obtained for the regular and irregular Coulomb wave-functions and their derivatives for $\rho = 2\eta$. A table of these functions is given, and a discussion is given to show how values may be obtained for $\rho \neq 2\eta$ by using Taylor's formula. A.

539.155

11346. On the validity of semi-empirical atomic mass-formula in the region of rare-earth nuclides. G. P. Dube and L. S. Singh. *Indian J. Phys.*, **28**, 177–82 (*April*, 1954).

It is shown that the Fermi's semi-empirical atomic mass formula is quite inadequate for the calculation of α-decay energy in the region of rare-earths. The calculated α-decay energy is much lower and even negative in several cases while the observed one ranges from 2 MeV to 4 MeV. A suitable correction term is added to the Fermi's mass-formula in the rare-earth region on the basis of Duckworth's new atomic mass-data. With the introduction of the correction-term the calculated α-disintegration energy is in agreement with the observed results. A.

539.155.2

11347. Separation of isotopes by means of surface diffusion in porous media. R. A. W. Haul. *Naturwissenschaften*, **41**, *No.* 11, 255–6 (1954).

Data for two typical experiments, one at 76·8°K and the other at 296·5°K are given in which O_2 containing 2% of $O^{16}O^{18}$ is allowed to flow under a pressure gradient through a porous plug. They show that at 76·8°K the separation appreciably exceeds that for pure Knudsen flow. W. GOOD

539.155.2 : 536.423.15

The vapour pressures of isotopic substances. Boron trichloride. *See Abstr.* 11004

RADIOACTIVITY . α-, β- AND γ-RAYS 539.16

539.16.08

11348. A new method for the analysis of radioactive bodies. J. Palacios and A. M. Baptista. *Rev. Fac. Ciênc. Univ. Lisboa B*, **2**, 49–58 (1952–53).

A simple way of comparing the radioactivity of samples and standards is described. It requires a cylindrical detector with a large "indifferent zone." The method can be applied to solids (pulverized) and to liquids but they must be hard γ-emitters. The samples and the standards are put in ring-shaped vessels around the central part of the indifferent zone. In order to eliminate any soft radiation a sheet of lead of suitable thickness is put between the counter and the sample or the standard. With this precaution, the correction for absorption can be neglected. A.

539.16.08

11349. Theory for the determination of the radioactive content of minerals. I. D. Palumbo. *Ann. Geofis.*, **6**, 229–38 (*April*, 1953) *In Italian.*

Considering a plane lamina containing α-radioactive atoms, whose thickness is great with respect to the range of the α-particles, and exposed to nuclear emulsion; the problem of the determination of the number of tracks produced in the emulsion by the α-particles is resolved as a function of their lengths, and of their horizontal and vertical projections, using the hypothesis that for α-particles, the range in materials is proportional to that in air. Formulae are obtained independent of any hypotheses on the state of equilibrium of the radioactive families present in the mineral. A.

539.16.08

11350. Theory for the determination of the radioactive content of minerals. II. D. PALUMBO. *Ann. Geofis.*, 6, 467–81 (*Oct.*, 1953) *In Italian.*

Using the general hypothesis that between the range η in material and the range ξ in the emulsion for α-particles of given energy the relation is $\eta = l(\xi)$, the general spectra of the horizontal and vertical projections and the effective lengths have been determined. The cases in which some of the above hypothesis are not verified are discussed. Numerical calculations are carried out after having made a hypothesis on the form of the function $l(\xi)$, whose constants have been calculated on the basis of the Bethe theory or from empirical data. The advantage is shown of taking in account the non-linearity of $l(\xi)$ in the applications of this technique to some problems of interest in geophysics. A.

539.16.08

11351. Scintillation counting of natural uranium foils. R. C. AXTMANN AND J. S. STUTHEIT. *Nucleonics*, **12**, 52–3 (*July*, 1954).

The use of a NaI crystal spectrometer to measure both fission products and the (n, γ) activation products in neutron-irradiated U foils, is described. If discriminator bias is set at 0·5 MeV then only fission product activities are counted. U^{239} and Np^{239} may be detected by low energy γ- and X-ray lines, in particular, 97·3 and 98·3 keV X-rays from Pu^{239}.

L. R. SHEPHERD

539.16.08

11352. Standardisation of beta-emitting nuclides. H. H. SELIGER AND A. SCHWEBEL. *Nucleonics*, **12**, 54–63 (*July*, 1954).

Methods used at the National Bureau of Standards for standardizing radioactive sources are described. Data on the decay and chemical forms of N.B.S. standard sources P^{32}, I^{131}, Co^{60}, Tl^{204}, C^{14}, Sr^{90}–Y^{90} and Au^{198} are given, together with results of intercalibrations of these standard sources by various institutions in Canada, U.K. and U.S.A.

L. R. SHEPHERD

539.16.08 : 551.594.14

11353. Measurement of atmospheric radioactivity with nuclear emulsions. E. MORASCHINELLI. *Ann. Geofis.*, 6, 561–7 (*Oct.*, 1953) *In Italian.*

The radioactive components are separated from the air by electrostatic separation onto an electrode plate, following which the plate is placed on the emulsion in order to record the emitted α-particles. From a microscopic examination of the emulsion the relative amount of the atmospheric radioactivity is determined and it is also possible to discriminate the elements of the thorium family from those of the uranium-radium family. A.

539.163.1

11354. Decay and growth tables for the naturally occurring radioactive series. H. W. KIRBY. *Analyt. Chem.*, **26**, 1063–71 (*June*, 1954).

539.163.1

11355. Sargent diagram and comparative half-lives for electron capture transitions. J. K. MAJOR AND L. C. BIEDENHARN. *Rev. mod. Phys.*, **26**, 321–6 (*July*, 1954).

Earlier studies by Thompson and Feather have been extended to lighter nuclei, wherever the half-life, branching ratios, and transition energy W are known, and a Sargent diagram constructed for 87 electron capture transitions; W, defined as the energy of the neutrino emitted during capture, must be deduced indirectly, from atomic mass differences, positron spectra, or inner bremsstrahlung. Known allowed transitions fall considerably below the line proposed by Feather, but the scatter of the points does not permit differentiation of Sargent curves for different degrees of forbiddenness. Comparative half-lives have been calculated for these capture transitions, and are tabulated and compared with ft values for β-emitters. The distribution of ft values are similar, and agreement is evident between most ft values for electron capture and positron emission in the same transformation. A.

539.163.1

11356. Disintegration rate of carbon-14. R. S. CASWELL, J. M. BRABANT AND A. SCHWEBEL. *J. Res. Nat. Bur. Stand.*, 53, 27–8 (*July*, 1954).

The energy emission rates of C^{14} samples have been measured with an extrapolation ionization chamber. From the energy emission rates, the disintegration rates are determined through knowledge of the average β-ray energy emitted per disintegration. From earlier data on the isotopic abundance a value for the half-life of C^{14} of 5900 ± 250 years is obtained.

A.

539.163.1

11357. Alpha half-lives of Cm^{244}, Cm^{245}, and Cm^{246}. A. M. FRIEDMAN, A. L. HARKNESS, P. R. FIELDS, M. H. STUDIER AND J. R. HUIZENGA. *Phys. Rev.*, **95**, 1501 (*Sept.* 15, 1954).

The half-lives measured from mass spectrometric analyses of curium and its plutonium daughters are 18·4 ± 0·5 yr (weighted average of present results and those reported previously), $1{\cdot}15 \pm 0{\cdot}5 \times 10^4$ yr, and $4{\cdot}0 \pm 0{\cdot}6 \times 10^3$ yr, respectively. A.

539.163.2

11358. Decay of Cs^{134m} (3·1 hr). A. W. SUNYAR, J. W. MIHELICH AND M. GOLDHABER. Letter in *Phys. Rev.*, **95**, 570–2 (*July* 15, 1954).

The K-conversion of the 127·1 ± 0·5 keV decay of Cs^{134m} was re-determined and confirms an $E3$ assignment. A new γ of 10·3 ± 0·4 keV was discovered, as well as the cross-over transition of 137·4 ± 0·5 keV. The resulting level scheme for Cs^{134} : 4 + (ground), 5 + (10·5 keV), 8 − (137·4 keV) is then consistent with the spin 8 of Cs^{134m} reported in Abstr. 11320–1 (1954). W. J. SWIATECKI

539.163.2

11359. The even mass isomers in lead. D. MAEDER, A. H. WAPSTRA, G. J. NIJGH AND L. T. M. ORNSTEIN. *Physica*, **20**, 521–38 (*Aug.*, 1954).

1·1 hr Pb^{204*} has been measured with scintillation and β-spectrometers. The isomeric transition has an energy of 913 ± 2 keV $[K/(L + M) = 1{\cdot}32 \pm 0{\cdot}07$, $\alpha_K = 0{\cdot}056 \pm 0{\cdot}003]$ and is considered to be of the $E5$ type; it is followed by a 374·5 ± 1 keV transition

[$\alpha_K = 0{\cdot}04 \pm 0{\cdot}015$, $K/(L+M) = 1{\cdot}76 \pm 0{\cdot}1$, $L/(M+N) = 3{\cdot}5 \pm 1$]. A $3{\cdot}5 \pm 0{\cdot}1$ hr isomer, discovered in these experiments, is ascribed to Pb^{202*}; it decays partly by a 128 ± 1 keV $E4$ transition followed by a $658{\cdot}2 \pm 1{\cdot}3$ keV $E1$ γ-ray, partly by a $788{\cdot}5 \pm 1$ keV $E5$ γ-ray; both modes of decay are followed by $421{\cdot}4 \pm 0{\cdot}5$ keV and $963 \pm 1{\cdot}5$ keV $E2$ γ-rays. Other conversion lines need further investigation to give them a consistent interpretation. The level schemes of Pb^{202}, Pb^{204} and Pb^{206} are discussed on the basis of configurations with two excited neutrons. In an appendix graphs of the relation between K/L and Z^2/E are presented. A.

539.163.2

11360. Nuclear levels in ^{60}Ni from the decay of ^{60}Cu. R. H. Nussbaum, R. van Lieshout, A. H. Wapstra, N. F. Verster, F. E. L. ten Haaf, G. J. Nijgh and L. T. M. Ornstein. *Physica*, **20**, 555–70 (*Aug.*, 1954).

Radiations from Cu^{60} have been investigated by means of a single channel NaI-scintillation spectrometer and a magnetic lens type β-ray spectrometer. Moreover, $\gamma - \gamma$ coincidences using two single-channel scintillation spectrometers have been measured. Three positron groups and eight γ-rays were found. A decay scheme is proposed in which probable spin and parity assignments are given to four new levels in Ni^{60} at $2{\cdot}18 \pm 0{\cdot}02$; $3{\cdot}11 \pm 0{\cdot}03$; $3{\cdot}52 \pm 0{\cdot}05$ and $3{\cdot}98 \pm 0{\cdot}04$ MeV. From the decay characteristics a spin 2^+ could be assigned unambiguously to the Cu^{60} ground state. The total mass-difference of $6{\cdot}23 \pm 0{\cdot}02$ MeV between Cu^{60} and Ni^{60} fits well into a linear plot of mass-differences of Cu–Ni and Cu–Zn isobars as a function of the mass number A. A discussion of some extrapolations from those plots to yet uncertain decay characteristics of nuclides in this region is added. A description of the components of the scintillation spectrometer and the two-fold coincidence circuit is given. A.

539.163.2

11361. Decay of the odd-odd isomer Tl^{198m}. T. O. Passell, M. C. Michel and I. Bergström. *Phys. Rev.*, **95**, 999–1002 (*Aug.* 15, 1954).

The electron spectrum of Tl^{198m} has been investigated in a 25 cm double-focusing β-spectrometer with a resolution of approximately $0{\cdot}4\%$. The electron lines have been assigned to three γ-rays with energies (in keV) $261{\cdot}5$, 284 and $48{\cdot}4$, respectively. The multipolarities assigned from conversion ratio and lifetime considerations are $M4$, $M1 + E2$ and $E2$, respectively. A tentative decay scheme is proposed which is consistent with all the available data. A.

539.163.2

11362. On the decay scheme of $^{214}_{84}$Po. F. Demichelis and R. Malvano. *Nuovo Cimento*, **12**, 358–68 (*Sept.*, 1954).

This has been investigated by a coincidence counting method γ–γ cascades existing in the Po^{214} decay spectrum have been identified. It has been possible to establish the energy level scheme for the γ-rays according to the known γ-ray spectrum and the cascades. The resulting scheme shows remarkable differences from those proposed in the past by other authors. A.

539.163.2

11363. On the decay scheme of $^{212}_{84}$Po(ThC′). F. Demichelis. *Nuovo Cimento*, **12**, 407–12 (*Sept.*, 1954).

From the experimental determination of the γ–γ cascades, a new level scheme was obtained. Partial lack of correspondence between γ-levels and long range α-levels was observed. This fact must be considered a general property for the radioactive nuclides emitting long range α-particles. A.

539.163.2

11364. Ground state of Re^{186}. L. Koerts. Letter in *Phys. Rev.*, **95**, 1358–9 (*Sept.* 1, 1954).

The β-spectrum of Re^{186} was examined in coincidence with the 137 keV γ-radiation; the shapes of all 3 negatron branches (E_{max} 1063, 926 and 300 keV) are allowed, so that the assignment 1+ for the ground state of Re^{186} should be maintained, contrary to the suggestion of Guss *et al.* (1954).

A. O. STANESBY

539.163.2

11365. Decay of Rb^{86}. W. S. Lyon and J. E. Strain. *Phys. Rev.*, **95**, 1500 (*Sept.* 15, 1954).

The γ-ray spectrum of Rb^{86} has been examined with a NaI(Tl) γ-ray spectrometer. Only the γ-ray of energy $1{\cdot}08$ MeV has been found; the fraction of decay proceeding through the transition is $0{\cdot}089 \pm 0{\cdot}005$. A.

539.163.2

11366. Energy levels in Po^{210}. J. W. Mihelich, A. W. Schardt and E. Segrè. *Phys. Rev.*, **95**, 1508–16 (*Sept.* 15, 1954).

The K-capture decay of At^{210} to levels in Po^{210} has been investigated in detail using conversion electron and γ-ray spectroscopy, and coincidence techniques. Ten transitions of the following energies and indicated multipolarities have been observed: $0{\cdot}047$ ($E2$), $0{\cdot}116$ ($M1$), $0{\cdot}246$ ($E2$), $0{\cdot}404$, $1{\cdot}185$ ($E2$), $1{\cdot}441$ ($E1$), $1{\cdot}487$ ($E1$), $1{\cdot}604$ ($E1$), $2{\cdot}23$ and $2{\cdot}6$ MeV. On the basis of these measurements, a consistent decay scheme may be proposed. Tentative γ–γ angular correlation measurements confirm this scheme. The spin and parity of At^{210} are probably 4−, 5− or 6±. Some information has also been obtained on other At isotopes. A weak 671 keV γ-ray not in coincidence (within $0{\cdot}1$ μsec) with K X-rays or α-particles appeared in the decay of At^{211}. γ-ray transitions of $83{\cdot}8$, $91{\cdot}1$, 195, 548 and 784 keV were observed in the decay of At^{209}. A.

539.163.2

11367. Nuclear levels in Ca^{43}. T. Lindqvist and A. C. C. Mitchell. *Phys. Rev.*, **95**, 1535–8 (*Sept.* 15, 1954).

These have been studied in the decay of Sc^{43} by positron emission to Ca^{43}. Levels have been found at $0{\cdot}369$, $0{\cdot}627$ and $0{\cdot}81$ MeV. In an earlier experiment, the decay of K^{43} by negatron emission was studied by the authors and nuclear levels were found in Ca^{43} at $0{\cdot}627$, $1{\cdot}00$, $1{\cdot}39$ and $1{\cdot}61$ MeV. The levels have been given configuration assignments. Theoretical discussion of the $(f_{7/2})^3$ configuration is compared with experimental results. A.

539.163.2

11368. The decay of Cs^{136}. J. L. Olsen and G. D. O'Kelley. *Phys. Rev.*, **95**, 1539–40 (*Sept.* 15, 1954).

The radiations from Cs^{136} have been investigated with β-spectrometers, scintillation spectrometers and a proportional counter spectrometer. β-particle groups of 341 keV and 657 keV energy were found, together with γ-ray groups of energy 67·2, 153, 162, 265, 335, 822, 1041, 1245, 1410, 2350 and 2490 keV. A decay scheme is proposed on the basis of γ-ray intensities and γ–γ coincidences. A.

539.163.2

11369. Decay scheme of I^{132}. H. L. Finston and W. Bernstein. *Phys. Rev.*, **96**, 71–4 (*Oct.* 1, 1954).

The radiations of 2·33 hr I^{132} have been investigated with magnetic lens and scintillation spectrometers. β-rays of 2·12 (18%), 1·52 (24%), 1·16 (23%) and 0·9 (20%) MeV have been identified. γ-rays of 0·528 (25%), 0·624 (6%), 0·673 (100%), 0·777 (75%), 0·96 (20%), 1·16 (8%), 1·40 (11%), 1·96 (5%) and 2·2 (2%) MeV have been observed, and their coincidences are tabulated. A possible decay scheme is proposed which is consistent with the experimental data. A.

539.163.2

11370. Identification of platinum-188. R. A. Naumann. *Phys. Rev.*, **96**, 90–2 (*Oct.* 1, 1954).

An unstable even-even neutron-deficient platinum isotope with a half-life of 10·3 ± 0·4 days has been prepared and assigned a mass number 188. The decay of this isotope results in unstable iridium 188, which in turn decays to a known excited state in stable osmium 188. A.

539.163.2

11371. Production of Nb^{93m} by the pile irradiation of niobium. R. P. Schuman. *Phys. Rev.*, **96**, 121 (*Oct.* 1, 1954).

Low-energy electrons and Nb *K* X-rays, believed to be due to the decay of the isomer Nb^{93m}, have been found in neutron-irradiated niobium. The electrons have energies of about 8·5 keV and 23 keV and are believed to be *K* and *L* conversion electrons from a 27 keV γ-ray. The half-life of the activity is about four years. A.

539.163.2

11372. Spectrometer studies of the radiations of some neutron-deficient isotopes of xenon and iodine. H. B. Mathur and E. K. Hyde. *Phys. Rev.*, **96**, 126–9 (*Oct.* 1, 1954).

Neutron-deficient isotopes of xenon have been produced by (p, xn) reactions with high-energy protons on potassium iodide targets. The xenon activities were deposited on foils by the glow discharge technique and their radioactive properties were measured. Ninteen-hour Xe^{122} decays by electron capture to 3·5 min I^{122}. γ-rays of 182 and 235 keV accompany this decay. I^{122} decays by emission of 3·12 MeV positrons. Xe^{123} decays with a 1·8 hr half-life into 13 hr I^{123}. Positrons of 1·7 ± 0·1 MeV, 150 keV γ-rays and X-rays are associated with this decay. Xe^{121} has a half-life of 40 ± 10 min for decay into 1·6 hr I^{121}. A.

539.165

11373. Recoil spectrum in the beta decay of Ne^{19}. W. P. Alford and D. R. Hamilton. Letter in *Phys. Rev.*, **95**, 1351–3 (*Sept.* 1, 1954).

The energy spectrum of recoiling atoms following the β^+-decay of Ne^{19} has been determined by a time-of-flight method. A value for α, the electron-neutrino angular correlation coefficient, of $-0·8 \pm 0·4$ was determined, corresponding to a mixture of tensor and scalar interactions in the β-decay. M. A. GRACE

539.165

11374. Beta spectra of Pr^{142}, Tm^{170}, and Rb^{86}. A. V. Pohm, W. E. Lewis, J. H. Talboy, Jr and E. N. Jensen. *Phys. Rev.*, **95**, 1523–9 (*Sept.* 15, 1954).

The β-spectra and γ-rays of the isotopes Tm^{170}, Pr^{142} and Rb^{86} have been examined with various types of spectrometers. An intermediate-image β-ray spectrometer with a 10% transmission and a 5·5% resolution was used to examine the total and coincidence β-spectra. Total β-spectra were also studied with a thin-lens spectrometer set to about 2% resolution. γ-rays were also studied with a scintillation spectrometer. The results of the investigation indicate that the 125-day activity of Tm^{170} has two β-groups with maximum energies of 970 ± 2 keV and 886 ± 9 keV. Their respective intensities are about 78% and 22%, and their respective log *ft* values are approximately 9·0 and 9·1. Both β-groups are assigned as first forbidden transitions with $\Delta I = \pm 1$, "yes." The single observed γ-ray of Tm^{170} is assigned as an *E*2 transition with an energy of 84·1 ± 0·4 keV. The 19·2 hr activity of Pr^{142} has two β-groups with maximum energies of 2166 ± 6 keV and 586 ± 15 keV. The 2166 keV β-group has a log *ft* value of about 7·8 and the 586 keV β-group has a log *ft* value of about 7·1. The log $[(Wo^2 - 1) ft]$ value of the 2166 keV β-group is 10·2. The intensities for the 2166 keV and 586 keV β-groups were found to be, respectively, 90–95% and 5–10%. The 2166 keV β-group is assigned as first forbidden with $\Delta I = 2$, "yes" and the 586 keV β-group as first forbidden with $\Delta I = 0$ or ± 1, "yes." The single observed γ-ray, having an energy of 1572 ± 8 keV, is tentatively assigned as an *E*2 or *M*1 transition. The *E*2 and $\Delta I = 0$, "yes" choices are probably correct. The 19·5 day activity of Rb^{86} has two β-groups with maximum energies of 1770 ± 4 keV and 680 ± 6 keV. Their intensities are about 88% and 12%, respectively. The log *ft* value for the 1770 keV β-group is about 8·5 and for the 680 keV β-group 7·8. The log $[(Wo^2 - 1) ft]$ value for the 1770 keV β-group is 9·7. This β-group is assigned as a first forbidden transition with $\Delta I = 2$, "yes," and the 680 keV β-group is tentatively assigned as first forbidden with $\Delta I = 0$, "yes." The single γ-ray has an energy of 1080 ± 6 keV and is tentatively assigned as an *E*2 transition. The Kurie plots of the 680 keV β-group of Rb^{86} and the 886 keV β-group of Tm^{170} were examined for deviations from a straight line. Within experimental error no deviation from a straight line was observed. A.

539.165

11375. The beta rays of thallium 204. J. C. Knight, T. H. Braid and H. O. W. Richardson. *Proc. Phys. Soc.* [*London*] *A*, **67**, 881–4 (*Oct.*, 1954).

This was measured using thin evaporated sources in a spheroidal field β-spectrometer. The end-point was found to be at 766 ± 2 keV. Small deviations were found from the unique shape of spectrum predicted for a first-forbidden transition with a spin change of two units. The deviations extend up to about 400 keV. The possibility that the decay is second forbidden and that the ground state of Tl^{204} has even parity is noted. A.

539.165 : 551.594.12

The intensity of β-ray ionization of K, U and Th. *See Abstr.* 11658

539.165.2 : 518.2

11376. Tables for the analysis of beta spectra. *Appl. Math. Ser. Nat. Bur. Stand., No.* 13, 61 *pp.* (1952).

The main tables give the values of the so-called "Fermi function" $f(Z, \eta) = \eta^{2+2S} e^{\pm\pi\delta} |\Gamma(1+S+i\delta)|^2$, covering all the values of Z that may be encountered in practice, and extending to η (momentum of electron) = 7 *mc*. [$S = \sqrt{(1 - Z^2/137^2)} - 1$, Z = atomic number, $\delta = Z\sqrt{(1 + \eta^2)}/137\eta$]. A descriptive introduction gives a brief review of the principles of analysis of β-spectra with instructions on the use of the tables, a worked example, and some auxiliary tables. The tables may find application in the study of other atomic problems.

539.165.2 : 539.152.1

11377. On beta emission and energy levels of the product nuclei. S. Banerjee and A. Mitra. *Indian J. theor. Phys.*, **1**, 133–70 (*March*, 1954).

An attempt has been made to give systematic level schemes for the β-active nuclei in the region $Z = 81$ to $Z = 92$ for the naturally occurring heavy radioactive isotopes. The total β-decay energy thus computed has been verified by considering (1) α-β branching and closed cycles in a series, (2) the relation between α-energy and the binding energy of last proton, (3) magic number drop of the binding energy of last proton, and (4) the decay-energy graph. A few predictions have been made regarding some undetermined β-energies. A.

539.166

11378. Gamma-ray spectra following the β-decay of Br^{82}, Sb^{124}, and I^{131}. D. C. Lu, W. H. Kelly and M. L. Wiedenbeck. *Phys. Rev.*, **95**, 1533–5 (*Sept.* 15, 1954).

Coincidences between the γ-rays following the β-decay of Br^{82}, Sb^{124} and I^{131} have been studied using the single scintillation crystal summing technique. A decay scheme for Br^{82} is proposed. The decay scheme of Sb^{124} proposed by Langer *et al.* is found to be consistent with the authors' data, as is the decay scheme of I^{131} proposed by Metzger and Deutsch and augmented by Emery. A.

539.166

11379. Two-step cascades in chlorine-36 and cadmium-114 neutron-capture gamma-ray spectra. A. L. Recksiedler and B. Hamermesh. *Phys. Rev.*, **96**, 109–12 (*Oct.* 1, 1954).

Two NaI(Tl) crystals were used in conjunction with a twenty- and a single-channel pulse-height analyser and a 5 microsecond coincidence circuit to determine cascade branches in the neutron-capture γ-ray emission from Cl^{36} and Cd^{114}. Several two-step cascades in Cl^{36} and one in Cd^{114} have been verified by the present methods. A.

539.166.74 : 539.172.3

11380. Nuclear resonance scattering of gamma-rays. K. G. Malmfors. *Ark. Fys.*, **6**, *Paper* 5, 49–56 (1952).

The intensity of 411 keV γ-rays elastically scattered from a mercury target increased when the Au^{198} source was heated to the melting point, in good agreement with calculations on the effect of thermal motion in counteracting the recoil of the emitting nucleus.

539.166.83

11381. Internal conversion in the *L*-subshells. J. B. Swan and R. D. Hill. *Austral. J. Phys.*, **6**, 371–9 (*Dec.*, 1953).

The relative intensities of conversion-electron lines from the three L-subshells have been determined for a number of γ-transitions, and the results compared with the theoretical values of Gellman, Griffith and Stanley (1952). Experiment has been shown to be in accord with theory. Calculations of theoretical K/L ratios indicate that the empirical curves of Goldhaber and Sunyar (1951) may need to be modified, especially for low Z. For a given Z^2/E, the K/L ratio increases with decreasing atomic number. A.

NUCLEAR REACTIONS 539.17

539.17 : 523.877

Nuclear processes in the stars (colloquium). *See Abstr.* 10763

539.172

11382. Anomalous event observed in photographic emulsion. J. H. Noon, M. F. Kaplon and J. Crussard. Letter in *Phys. Rev.*, **95**, 1103–4 (*Aug.* 15, 1954).

A fast Be nucleus interacts to produce a star, two of whose prongs are relativistic particles of charge three and two. In this event, the charge on the fast heavy fragments from the interaction exceeds the charge on the parent nucleus. Different possible reactions to explain the event are discussed. The case provides some evidence for the formation of an excited nucleus by addition of a positive charge to a break-up fragment. P. ROTHWELL

539.172 : 537.591.8

Nuclear reactions due to cosmic rays. *See Abstr.* 11186–90

539.172

11383. Absorption of negative pions in deuterium: parity of the pion. W. Chinowsky and J. Steinberger. *Phys. Rev.*, **95**, 1561–4 (*Sept.* 15, 1954).

The reaction $\pi^- + d \rightarrow 2n$ has been observed by detecting the two neutrons in coincidence with slow negative mesons incident on a liquid deuterium target. The observed angular correlation of the two neutrons confirms the identification of the process. The process is therefore not forbidden, and this fact may be used to establish the odd relative parity of the pion and the nucleon. A.

539.172.13

11384. Angular distribution of deuterons from $^9Be(p, d)^8Be$. J. DĄBROWSKI AND J. SAWICKI. Letter in *Nuovo Cimento*, **12**, 293–5 (*Aug*., 1954).

Born approximation is used, and the interaction between the neutron and Be^8 nucleus is neglected. Theoretical curves for 6·5 and 22 MeV protons are obtained and compared with experiment. G. E. BROWN

539.172.13

11385. Elastic scattering of protons by O^{16} between 3 and 7 MeV. M. SEMPERT, H. SCHNEIDER AND M. MARTIN. *Helv. phys. Acta*, **27**, *No*. 4, 313–16 (1954) *In German.*

The elastically scattered protons from O^{16} have been measured as a function of the incident proton energy at nine different scattering angles between 30° and 150°. The measurements give information about the excited states of the compound nucleus F^{17}. The experimental results were analysed by means of scattering theory using graphical methods. In the case of the following levels spin and parity could be given: 4·5 MeV ($3/2^-$), 4·6 MeV ($3/2^+$), 5·15 MeV ($1/2^+$) and 6·65 MeV ($1/2^+$). These four resonances have a level-width of several hundred keV. Between excitation energies of 5 and 7 MeV were also found eight sharp resonances with level widths $\Gamma < 25$ keV. The experimental widths are compared with theoretical values derived from the model of single particle excitation. The ratio $\Gamma_{exp.}/\Gamma_{theor.}$ shows a rapid decrease at 5 MeV, indicating the increasing probability of multiple particle or core excitation at higher energies. A.

539.172.13

11386. On the reaction $^{23}Na(p, \gamma)^{24}Mg$ and the energy levels of ^{24}Mg. O. H. TURNER. *Austral. J. Phys.*, **6**, 380–90 (*Dec*., 1953).

The energies of at least 20 γ-rays emitted from the 302 kV resonance level of $Na^{23}(p, \gamma)Mg^{24}$ have been measured with sodium iodide crystals employed as (*a*) single crystal spectrometer, (*b*) scintillation pair spectrometer, (*c*) "cascade" spectrometer. A tentative decay scheme involving levels at 1·38, 4·25, 5·3, 5·8 or 6·2, 7·73, 8·57, 10·60, 11·23, 11·62 and 12·03 MeV is proposed for Mg^{24}. The effect of isotopic spin on the transition probabilities is discussed and some spin and parity assignments made. The resonance concerned has been determined as being at 302·2 ± 0·6 kV, and is believed to be less than 50 V wide. A.

539.172.13

11387. Reactions of cesium with protons at 60, 80, 100, 150 and 240 MeV. R. W. FINK AND E. O. WIIG. *Phys. Rev.*, **96**, 185–7 (*Oct*. 1, 1954).

Absolute production cross-sections have been determined for certain isotopes of barium, caesium, iodine and tellurium produced by reactions of caesium with protons of these energies. The yields are based on the known cross-section for the monitor reaction $Al^{27}(p, 3pn)Na^{24}$. In the region up to 100 MeV the data indicate that the yields are largely explained on the basis of an evaporation mechanism which competes with the prompt knock-on optical model to an extent which decreases rapidly with increasing energy because of increasing nuclear transparency. The neutron pick-up reaction manifests itself in extraordinarily large yields of Cs^{132} and to a lesser extent in the yields of Cs^{131}. Formation of small amounts of neutron-excess iodine isotopes argues for α-particle fragmentation especially at the lower bombardment energies. A.

539.172.13

11388. Excitation function of the $C^{12}(p, pn)C^{11}$ reaction in the BeV region. R. L. WOLFGANG AND G. FRIEDLANDER. *Phys. Rev.*, **96**, 190–1 (*Oct*. 1, 1954).

The ratio of the cross-section of the $C^{12}(p, pn)C^{11}$ reaction to the cross-section of the $Al^{27}(p, 3pn)Na^{24}$ reaction has been measured in the energy range 400 MeV to 3 BeV. This ratio as well as the excitation curve of the $C^{12}(p, pn)C^{11}$ reaction appear to be quite insensitive functions of the energy in the range studied. A possible interpretation is discussed. A.

539.172.13

11389. The reaction $p + p \rightarrow \pi^+ + d$ with polarized protons. F. S. CRAWFORD, JR AND M. L. STEVENSON. Letter in *Phys. Rev.*, **95**, 1112 (*Aug*. 15, 1954).

Positive results for left–right asymmetries are obtained in experiments at 317 and 310 MeV, allowing evaluation of a parameter in the phenomenological theory of Brueckner and Watson. G. E. BROWN

539.172.13

11390. Gamma radiation from the reaction $^{11}B(p,\gamma)^{12}C$. P. J. GRANT, F. C. FLACK, J. G. RUTHERGLEN AND W. M. DEUCHARS. *Proc. Phys. Soc. [London] A*, **67**, 751–6 (*Sept*., 1954).

The angular distributions of the 16·1, 11·7 and 4·4 MeV γ-rays were determined at a number of bombarding energies. The angular distribution of the 16 MeV radiation is shown to be consistent with the accepted assignment of $J = 2^+$ to the resonance at $E_p = 163$ keV, and shows interference involving a higher level having $J = 1^-$ which is identified with the broad resonance at $E_p = 1390$ keV. The angular distribution of the 11·7 MeV radiation shows interference between the resonances at 680 and 1390 keV and suggests the assignment $J = 2^+$ to the 680 keV resonance. A.

539.172.13

11391. Neutrons from the proton bombardment of B^{10}. F. AJZENBERG AND W. FRANZEN. *Phys. Rev.*, **95**, 1531–3 (*Sept*. 15, 1954).

The $B^{10}(p,n)C^{10}$ reaction has been investigated at 30, 60, 90, 120 and 150 degrees in the laboratory system by the method of proton recoils in thick photographic emulsions. The mean energy of the incident protons was 17·2 ± 0·15 MeV. The results indicate a ground-state Q-value of $-4·35 \pm 0·2$ MeV, yielding a mass defect of 18·6 MeV for C^{10} in good agreement with β-decay results. The data also indicate a level in C^{10} at 3·34 ± 0·2 MeV and partly resolved levels at excitation energies $\gtrsim 5$ MeV. The angular distributions of the neutrons to the ground state and to the 3·34 MeV state are shown. A.

539.172.13

11392. Reactions of 380-MeV protons with cobalt. E. BELMONT AND J. M. MILLER. *Phys. Rev.*, **95**, 1554–61 (*Sept*. 15, 1954).

The individual cross-sections for the formation of 37 different radioactive products that result from the inelastic interaction of 370 MeV protons with cobalt nuclei have been determined. The results are interpreted in the light of a model that emphasizes the importance of the evaporation of particles from an excited nucleus to give the final products of the collision. By the interpolation of the formation cross-sections of the undetected product nuclei, an estimation is made of the total inelastic interaction cross-section and the differential cross-section for the transfer of a given excitation energy to the target nucleus in an inelastic collision. A.

539.172.13

11393. Reduced widths from (*d, p*) reactions. Y. Fujimoto, K. Kikuchi and S. Yoshida. *Progr. theor. Phys.*, **11**, 264–72 (*March*, 1954).

Reduced widths of low-lying levels are calculated from experimental deuteron stripping cross-sections on the basis of Butler theory. The validity of the approximation is examined by these reduced widths. The structure of low-lying levels is discussed from the results. A.

539.172.13

11394. Elastic scattering of 7·86 MeV deuterons by carbon-12. J. Catalá, F. Senent and J. Casanova. *An. Real. Soc. Españ. Fís. Quím.*, **50** (A), 145–50 (*July–Aug.*, 1954) *In Spanish.*

The angular distribution of the 7·8 MeV deuterons elastically scattered by C^{12}, in the centre of mass system, has been determined and plotted together with the results obtained from the well-known Rutherford scattering formula, to show the special interaction deuteron-C^{12}. A.

539.172.13

11395. Energy levels of Al^{26}. C. P. Browne. Letter in *Phys. Rev.*, **95**, 860–1 (*Aug.* 1, 1954).

Bombardments by 5–7 MeV *d*'s from an electrostatic generator produce α-groups according to $Si^{28}(d, \alpha)Al^{26}$ whose analysis reveals excited states in Al^{26} of isobaric spin $T = 0$ and $E = 0{\cdot}418$, $1{\cdot}052$, $1{\cdot}750$ $(1{\cdot}846)$, $2{\cdot}064$. W. J. SWIATECKI

539.172.13

11396. Polarization of high-energy deuterons. O. Chamberlain, E. Segrè, R. Tripp, C. Wiegand and T. Ypsilantis. Letter in *Phys. Rev.*, **95**, 1104–5 (*Aug.* 15, 1954).

Double scattering by C of 167 MeV deuterons was investigated as function of the second azimuth ϕ_2. The absence of a $\cos 2\phi_2$ term in the result: $d\sigma/d\Omega$ (in 10^{-27} cm²/steradian) $= 50{\cdot}3 \pm 2{\cdot}2 + (15{\cdot}3 \pm 1{\cdot}9) \cos \phi_2$, is consistent with the assumption that the polarization originates in an **L . S** coupling. W. J. SWIATECKI

539.172.13

11397. Coulomb effects in stripping reactions. J. Yoccoz. *Proc. Phys. Soc.* [*London*] *A*, **67**, 813–20 (*Sept.*, 1954).

The Coulomb effect in (*d, p*) and (*d, n*) stripping reactions at low energies is investigated. It is shown that the angular distribution is flattened, the absolute cross-section is decreased, and that the Coulomb field contributes to the polarization of the spins of the particles. The calculations are valid for light nuclei only. A.

539.172.13

11398. Energy levels in Be^8 from $Li^7(d, n)Be^8$. C. C. Trail and C. H. Johnson. Letter in *Phys. Rev.*, **95**, 1363–4 (*Sept.* 1, 1954).

The neutron spectrum resulting from the bombardment of separated metallic Li^7 by 2 MeV deuterons was studied at 0° using a recoil proton spectrometer consisting of a polyethylene radiator and 2 proportional counters in coincidence with a 20-channel NaI scintillation counter. Neutron groups were found corresponding to the formation of Be^8 in the ground state and in an excited state at 3 MeV; neutron groups corresponding to a Be^8 excitation of 4–5 MeV and of 7·5 MeV were $<0{\cdot}1$ and $<0{\cdot}2$ respectively of the intensity of the ground state group. The spectrum is to be studied at other angles. A. O. STANESBY

539.172.13

11399. Mass-spectrometric study of deuteron-induced reactions in iodine. S. J. Balestrini. *Phys. Rev.*, **95**, 1502–8 (*Sept.* 15, 1954).

Absolute cross-sections for the (*d*, 2*n*), (*d*, 3*n*) and (*d, p*) plus (*d, n*) reactions in I^{127} have been measured for deuteron energies up to 18 MeV by the method of isotope dilution. The stable and long-lived isotopes of xenon produced by deuteron bombardment of stacked foils of KI were distilled from these foils, were mixed with known quantities of atmospheric xenon, and after purification were examined for isotopic composition in a mass spectrometer. For purposes of comparison, relative activation cross-sections for the (*d, p*) reaction on I^{127} were measured by standard counting techniques. The cross-section for the formation of the compound nucleus Xe^{129} is found to be in good agreement with theoretical calculations if the interaction radius is taken to be $(1{\cdot}3A^{\frac{1}{3}} + 1{\cdot}21)10^{-13}$ cm. The curves for the yield of I^{128} and for the total production of Xe^{128} are of the same shape. It is argued that the (*d, p*) and (*d, n*) stripping reactions are the principal mechanism for the formation of this latter nuclide. A precise mass-spectrometric determination of the half-life of Xe^{127} yields a value of $36{\cdot}406 \pm 0{\cdot}016$ days. A.

539.172.13

11400. Energy and angular distribution of protons from deuteron bombardment of nickel. W. W. Pratt. *Phys. Rev.*, **95**, 1517–23 (*Sept.* 15, 1954).

The energy spectrum and angular distribution of protons resulting from 3·03 MeV deuteron bombardment of Ni^{58} and Ni^{60} have been studied by means of a nuclear emulsion technique. Three previously unreported energy levels in Ni^{59} have been found. The angular distribution of the protons indicates that the reaction is primarily due to compound nucleus formation. A.

539.172.13

11401. Differential cross sections for the $C^{12}(d,p)C^{13}$ and $C^{13}(d,t)C^{12}$ reactions. H. D. Holmgren, J. M. Blair, B. E. Simmons, T. F. Stratton and R. V. Stuart. *Phys. Rev.*, **95**, 1544–50 (*Sept.* 15, 1954).

The differential cross-section for the $C^{12}(d, p)C^{13}$ reaction has been measured for 3·29 MeV deuterons over an angular range from 5° to 140°. It was found to have a maximum near 25°, a minimum near 80°

and another increase at higher angles. Over the same range, the $C^{13}(d, t)C^{12}$ reaction has a differential cross-section for 3·29 MeV deuterons which shows a maximum at 12°, a minimum at 57° and a small rise at higher angles. For 2·19 MeV deuterons the structure of $C^{13}(d, t)C^{12}$ differential cross-section is broader, with the maximum occurring at 17°. The experimental results have been compared with the results theoretically expected for stripping reactions. A.

539.172.13

11402. Angular distributions of protons from $Na^{23}(d,p)Na^{24}$ and $Ti^{47,48}(d,p)Ti^{48,49}$. M. M. Bretscher, J. O. Alderman, A. Elwyn and F. B. Shull. *Phys. Rev.*, **96**, 103–9 (*Oct.* 1, 1954).

Sodium and titanium targets were bombarded with 10 MeV deuterons, and angular distributions of protons from the stripping reaction were observed with arrays of nuclear emulsions. Absorbing foils in front of each emulsion were arranged so that the integrated flux of protons in a limited energy range could be determined. Distributions were found for each of the four most energetic proton groups from sodium, corresponding to Q values of 4·731 (ground state), 4·259, 4·167 and 3·390 MeV. The data were compared with the Butler theory, and l_n values of 2, 2, 0 and 0, respectively, were necessary to fit theory to data. With Ti^{47} targets, l_n values of 3, 1 (and 3?), 1 and 1, respectively, were determined for proton groups corresponding to Q values of 8·14, 6·81, 5·83 and 4·83 MeV. With Ti^{48} targets, l_n values of 3, 1, 1 and either 1 or 2 were determined for proton groups corresponding to Q values of 5·81 (ground state), 4·46, 4·11 and 3·40 MeV, respectively. From these data, parity and possible spin values for the various states of Na^{24}, Ti^{48} and Ti^{49} are deduced. A.

539.172.13

11403. Excited states in B^{10} and Be^{8}. T. W. Bonner and C. F. Cook. *Phys. Rev.*, **96**, 122–5 (*Oct.* 1, 1954).

A new technique for detecting neutron thresholds by using a slow neutron counter and a conventional long counter is described. By means of this technique, neutron thresholds from the deuteron bombardment of Li^{7} have been studied at energies from 0·4 MeV to 4·7 MeV. Thresholds were observed at energies of 1·34, 2·18, 3·37, 3·6 and 4·07 MeV. These thresholds indicate excitation levels in Be^{8} at 16·06, 16·72, 17·65, 17·8 and 18·19 MeV. By the same method, excited states of B^{10} from the $Be^{9}(d, n)B^{10}$ reaction were found at 4·78, 5·11, 5·17, 5·93, 6·06, 6·16, 6·43 and 6·57 MeV. A.

539.172.13 : 537.534.74

11404. Elastic scattering of deuterons by He^{3}. R. J. S. Brown, K. F. Famularo, H. D. Holmgren, D. Rankin and T. F. Stratton. *Phys. Rev.*, **96**, 80–2 (*Oct.* 1, 1954).

Differential cross-sections for the elastic scattering of deuterons by He^{3} have been measured at laboratory energies of 1·02, 1·50, 2·00, 2·50, 3·00 and 3·25 MeV for nine centre-of-mass angles ranging from 45° to 125°. At each deuteron energy the cross-section passes through a minimum in the vicinity of 90°, with the minimum shifting to slightly higher angles as the bombarding energy increases. The cross-section decreases with increasing energy for each angle investigated. At 3·25 MeV the cross-section passes through a minimum of 16 millibarns at 100° and rises to approximately 80 millibarns at 45° and 125°. A comparison of the results for the scattering of deuterons by He^{3} and by the mirror nucleus H^{3} shows the cross-sections to be approximately the same except at the lowest energies and forward angles. A.

539.172.13

11405. The angular distribution of the $Li^{7}(t, \alpha)He^{6}$ reactions at 240 keV triton energy. E. Almqvist, T. P. Pepper and P. Lorrain. *Canad. J. Phys.*, **32**, 621–9 (*Oct.*, 1954).

The angular distributions of the $Li^{7}(t, \alpha)He^{6}$ reactions have been measured between 41° and 139° to the beam in the laboratory system. The distribution of the 5·95 MeV α-particles associated with the formation of ground state He^{6} is of the form $1 - 0{\cdot}66(\pm 0{\cdot}06) \cos^2 \phi$ in the centre of mass system. The 4·95 MeV α-particles associated with the formation of the first excited state of He^{6} are distributed isotropically within ±8%. These results are consistent with the expectation that the ground state of He^{6} has spin 0 and the first excited state spin 2 and suggest that the compound state, Be^{10}, has $J = 2$. A.

539.172.13

11406. The forward displacement of the nitrogen isotope of mass 13 produced by bombardment of aluminium with the isotope 14. K. F. Chackett and J. H. Fremlin. *Phil. Mag.*, **45**, 735–41 (*July*, 1954).

The relative yields of N^{13} produced in stacked foils bombarded by $^{14}N^{6+}$ ions in the Birmingham cyclotron have been studied. These show strong forward displacements of the N^{13} compared with other radioactive products. The displacements are consistent with the hypothesis that the N^{13} is formed by a reaction analogous to deuteron stripping in which the N^{13} nuclei have a considerable proportion of the forward momentum of the bombarding ions. A.

539.172.3

11407. Angular distribution of photoprotons from nitrogen. B. M. Spicer. *Austral. J. Phys.*, **6**, 391–6 (*Dec.*, 1953).

The energy distributions and angular distributions of protons ejected from nitrogen by 11·5 MeV bremsstrahlung have been measured. From the results obtained, it is concluded that the (γ, p) reaction in nitrogen is due to magnetic dipole and electric quadrupole transitions for photon energies of 7·6–11 MeV. A.

539.172.3

11408. Nuclear elastic scattering of photons. E. Hayward and E. G. Fuller. Letter in *Phys. Rev.*, **95**, 1106–7 (*Aug.* 15, 1954).

Earlier measurements [Abstr. 8643 (1954)] have been extended to include 4 to 28 MeV γ-ray energies and Cu, Mn, Sn, Au, Bi and Pb targets. All elements except Au show a scattering peak near the (γ, n) threshold, in addition to the "giant-resonance" peak. The anomalous behaviour of Au is probably associated with a large inelastic scattering cross-section. J. J. WILKINS

539.172.3

11409. The absolute photo-neutron yield from copper for the lithium gamma-rays. J. H. Carver and E. Kondaiah. Letter in *Phil. Mag.*, **45**, 988–90 (*Sept.*, 1954).

This has been measured using thin-target, Li$^7(p, \gamma)$ resonance radiation incident on natural copper, and using the Szilard–Chalmers method for neutron detection. A cross-section value $(85 \pm 15) \times 10^{-27}$ cm is given. J. J. WILKINS

539.172.3

11410. Photodisintegration of deuterium by 165-MeV X-rays. E. A. Whalin, Jr. Letter in *Phys. Rev.*, **95**, 1362–3 (*Sept.* 1, 1954).

Angular distributions and total yields of photo-protons have been measured for centre-of-mass X-ray energies from 60 up to 130 MeV. A decreasing $\sin^2 \theta$ component and an approximately constant isotropic component are reported. The theoretical interpretation of the results is discussed. J. J. WILKINS

539.172.3

11411. Resonance absorption of gamma radiation by O^{16} nuclei. J. G. Campbell. Letter in *Phys. Rev.*, **95**, 1357–8 (*Sept.* 1, 1954).

Using Li$^7(p, \gamma)$ radiation, an O$^{16}(\gamma, n)$O^{15} cross-section resonance has been detected at $17{\cdot}721 \pm 0{\cdot}010$ MeV γ-ray energy. J. J. WILKINS

539.172.3

11412. A$^{40}(\gamma, n)$ threshold and the mass of A^{39}. J. Halpern, R. Nathans and P. F. Yergin. *Phys. Rev.*, **95**, 1529–30 (*Sept.* 15, 1954).

The A$^{40}(\gamma, n)$A^{39} reaction is found to have a threshold at $9{\cdot}85 \pm 0{\cdot}15$ MeV. Using the most recent mass spectrograph measurements for the mass of A^{40}, the mass of A^{39} is calculated to have a value of $38{\cdot}97681 \pm 0{\cdot}00020$. The relationship of this measurement to other reaction energy data is discussed. A.

539.172.3

11413. Yield of alpha particles from photonuclear reactions at 23-MeV bremsstrahlung. L. H. Greenberg, J. G. V. Taylor and R. N. H. Haslam. *Phys. Rev.*, **95**, 1540–3 (*Sept.* 15, 1954).

The yield of α-particles from (γ, α) reactions and other photoreactions involving α-particle emission from 9 elements up to atomic number 58 is given. Much of the data used have been previously published but further information has been obtained on the reactions in carbon, oxygen and bromine. Original measurements have been made for the (γ, α) reactions in vanadium and silver. The yield is a maximum in the region of copper and drops rapidly with increasing atomic number. There is evidence that at high atomic numbers, reactions involving the emission of another particle as well as the α-particle predominate over just single α-particle emission. A.

539.172.3

11414. Low-energy photofission yields for U^{238}. H. G. Richter and C. D. Coryell. *Phys. Rev.*, **95**, 1550–3 (*Sept.* 15, 1954).

The pattern of mass number dependence of fission yield has been determined in the photofission of natural uranium (U^{238}) by 16 MeV electrons from the linear accelerator. The effective photon energies were principally 9–14 MeV. Yields were determined by quantitative radiochemical isolation and close approximation to absolute β-counting for 19 chains. The peak-to-valley ratio is 110, the highest found yet outside of low-energy neutron studies. A spike in fission yields was found near mass number 133. Yields were also obtained for a number of chains in photofission with 10 MeV electrons. A.

539.172.3

11415. Absolute cross section *versus* energy of the Cu$^{63}(\gamma, n)$ and Cu$^{63}(\gamma, 2n)$ reactions. A. I. Berman and K. L. Brown. *Phys. Rev.*, **96**, 83–9 (*Oct.* 1, 1954).

Experimental values were found for the absolute cross-section of both Cu$^{63}(\gamma, n)$ and $(\gamma, 2n)$ reactions *v.* quantum energy from threshold to 36 MeV. Statistical and systematic errors were limited by the use of (*a*) the direct electron beam of the Stanford 36 MeV linear accelerator, which produced bremsstrahlung immediately before and within the copper foils under bombardment, (*b*) an electron-beam collector which recorded the total accumulated charge in the incident flux, (*c*) a 4π scintillation counter which measured the activity of the resultant Cu^{62} and Cu^{61}, and (*d*) electroplated foils of separated Cu^{63} isotope. The cross-section curves of the two reactions are similar—both rise rapidly to a maximum value about 6 MeV above threshold and then fall to zero almost as rapidly. The integrated cross-sections were found to be $0{\cdot}55 \pm 0{\cdot}03$ and $0{\cdot}081$ MeV-barns for the (γ, n) and $(\gamma, 2n)$ reactions, respectively. The $(\gamma, 2n)$ threshold is $20{\cdot}0 \pm 0{\cdot}5$ MeV. A precision of $0{\cdot}5\%$ was attained in the relative (γ, n) activation points and 5% in the absolute cross-section integrated over energy. The corresponding errors in the $(\gamma, 2n)$ data were 5 and 20%; the latter value includes the effect of a 10% uncertainty in the currently published data on the electron-capture to positron-emission ratio of Cu^{61}. A.

539.172.4

11416. Different oxidation states of manganese produced by the Fe(n, p)Mn reaction. C. Lakshman Rao, H. D. Sharma and J. Shankar. *Proc. Indian Acad. Sci. A*, **40**, 102–5 (*Aug.*, 1954).

Formation of Mn^{54} by (n, p) reaction in Fe^{54} has been confirmed. It has been found that Mn^{54} thus formed occurs in the several oxidation states. A.

539.172.4

11417. Polarization in *n-p* scattering at 100–200 MeV. A. Roberts, J. Tinlot and E. M. Hafner. Letter in *Phys. Rev.*, **95**, 1099–100 (*Aug.* 15, 1954).

Further results of charge-exchange scattering with C as 1st target ($\theta_1 = 15°$ or $30°$) and 2nd targets C, Be, H. The polarization in *n-p* scattering is small up to 45°: the angular dependence is inconsistent with a Serber potential [see Abstr. 6236 (1953), 8619 (1954)]. W. J. SWIATECKI

539.172.4

11418. Equations for heterogeneous reactors. A. Medina. *Rev. Mexicana Fis.*, **3**, 84–103 (*April*, 1954) *In Spanish.*

By means of a systematic averaging process applied to a heterogeneous pile, it is possible to obtain a simple set of design equations giving good agreement with experiment for thermal reactors. Such a process is developed in this paper, where it is shown that by the use of suitable constants, the general behaviour of a pile can be predicted within a very reasonable degree of accuracy. A.

539.172.4

11419. On the kinetic energy of fission-fragments from U^{235}. G. P. Dube and L. S. Singh. *Indian J. Phys.*, **28**, 227–31 (*May*, 1954).

It is shown that Fermi's semi-empirical mass-formula used for the estimation of kinetic energy of fission-fragments gives values less than the observed ones by about 30 MeV. Applying a suitable correction-term based on Duckworth's recent mass-spectrographic measurements the kinetic energy of fission fragments has been estimated to be 171·2 MeV which agrees with the recent measurement of 167·1 MeV. A.

539.172.4

11420. Identification of gadolinium and terbium radioisotopes as fission products of U^{235}. E. C. Freiling, L. R. Bunney and N. E. Ballou. *Phys. Rev.*, **96**, 102 (*Oct.* 1, 1954).

The identification of Gd^{159} and Tb^{161} as products of the neutron-induced fission of U^{235} has been confirmed. By a comparison of counting rates with Mo^{99}, the fission yields have been estimated to be $1 \cdot 1 \times 10^{-3}$ and $8 \times 10^{-5}\%$, respectively. A.

539.172.4

11421. Ratio of $\bar{\Gamma}_n^0/\bar{D}$ for slow neutron resonances. R. S. Carter, J. A. Harvey, D. J. Hughes and V. E. Pilcher. *Phys. Rev.*, **96**, 113–14 (*Oct.* 1, 1954).

A survey has been made of resonance parameters of the heavy elements which have been measured recently. The variation of the ratio $\bar{\Gamma}_n^0/\bar{D}$ with atomic weight has been compared with theoretical predictions. A maximum was found in the ratio $\bar{\Gamma}_n^0/\bar{D}$ at atomic weight of approximately 160 in fair agreement with the more recent theories of neutron scattering by nuclei. The experimental data, however, are not sufficiently accurate to make a choice between the new theories which have been proposed. A.

539.172.4

11422. The interaction of neutrons with matter studied with a pulsed neutron source. G. F. von Dardel. *K. Tekn. Högsk. Handl.*, *No.* 75, 104 *pp.* (1954).

An approximation derivation has been made of the slowing-down process of a fast neutron burst by free nuclei in light or heavy water, in cadmium and, to a limited extent, in boron. The resulting neutron velocity distributions have been compared with experimentally determined time distributions of the neutron flux from light and heavy water moderators at various temperatures. The method uses a 40-channel analyser to measure the neutron energy spectrum as a function of time after a low-intensity pulse of neutrons (150 keV pulsed Philips set, DD zirconium or heavy ice targets, small, 1 cm^3, enriched BF_3 chambers close to a 19 cm cube moderator to avoid time of flight effects) the energy of the neutrons being determined by sheet absorbers of cadmium or boron interposed between the moderator and the detector. The thermal neutron transmission as a function of moderator temperature has been investigated from 98°K to 354°K and, for both light and heavy water at room temperature, the experimental results support a Maxwellian velocity distribution in the thermal region, but for ordinary water at 98°K, however, the intramolecular binding lengthens the slowing-down process more than is theoretically predicted. The interpretation of the decay constant of the neutron flux in terms of the mean life for absorption has been considered, but the value of the diffusion coefficient so obtained for light water does not agree with other experimental values. Better agreement is found for heavy water. A cooling effect due to neutron leakage from a finite moderator is predicted and quantitatively confirmed for heavy water. D. R. CHICK

539.172.4

11423. On the mechanism of fission at very high energy. L. Marquez. Letter in *Nuovo Cimento*, **12**, 288–9 (*Aug.*, 1954).

In fissions produced by incoming particles of several hundred MeV, evidence seems to point to the emission of neutrons occurring after the process of fission, rather than before as considered in Abstr. 485 (1950). A way of testing this is to see if the neutrons are isotropic, as they would be in the latter case, or asymmetric. For incoming neutrons of 100 MeV, the ratio of the intensity at 0° to that at 90° is 1·8, if the emission of neutrons occurs after fission.

G. E. BROWN

539.172.4

11424. Introduction to nuclear engineering. R. Stephenson. *New York: McGraw-Hill* (1954) 387 + xii *pp.* + 137 *figs.*

Review in *Rev. Sci. Instrum.*, **25**, 820–1 (*Aug.*, 1954).

539.172.4

11425. Automatic control of a nuclear reactor—application to the Saclay pile (P.2). P. Bonnaure, P. Braffort, I. Pelchowitch and J. Weill. *J. nuclear Energy*, **1**, 24–38 (*Aug.*, 1954) *In French.*

It is actuated by an error signal corrected by a signal which is proportional to the reactivity. It is demonstrated that such a system is stable. Experimental results obtained with the Saclay pile are presented and are shown to agree with the theory. Stability of better than 0·1% is easily achieved in steady runs, as well as safety when power is changed. A.

539.172.4

11426. Operational features of Zephyr. J. E. R. Holmes, D. D. McVicar, H. Rose, L. R. Shepherd, R. D. Smith and A. M. Smith. *J. nuclear Energy*, **1**, 47–52 (*Aug.*, 1954).

Zephyr is a small low-power fast reactor with a core made up of plutonium and natural uranium sections surrounded by a uranium envelope. The reactor is controlled by moving sections of uranium near the core to vary the fraction of neutrons that may escape from the latter. Power level measurement is carried out by pulse-operated fission chambers with both linear and logarithmic ratemeters as indicators. The reactor became critical for the first time on the 5th February (1954). Initial studies have included the investigation of the delayed neutrons and their influence on the reactor kinetics A.

539.172.4

11427. Effect of photoneutrons on the transfer function of a heavy-water reactor. A. LUNDBY. *J. nuclear Energy*, **1**, 53–6 (*Aug*., 1954).

The transfer function of JEEP as a function of the photoneutron intensity in the reactor has been measured and compared with theory. Reactor oscillator experiments are found to be ambiguous at power levels below a few kilowatts. A.

539.172.4

11428. Liquid metal fuel reactor systems for power. C. WILLIAMS AND F. T. MILES. *Nucleonics*, **12,** 11–13 (*July*, 1954).

A possible thermal type breeder reactor using U^{233} fuel in solution with molten Bi and breeding fresh U^{233} in a Th blanket is described. The molten fuel is circulated through channels in the graphite moderator of the core and thence through an external heat exchanger. Continuous processing is incorporated in the fuel circuit, gaseous fission products being flushed out by an inert gas and rare earth products removed by a fused salt extraction process. The Th in the blanket would be in the form Th_3Bi_5 dispersed in molten Bi, which would be circulated through a heat exchanger and a fused salt extraction system to remove the Pa^{233} and U^{233} bred in the source material. L. R. SHEPHERD

539.172.4

11429. Liquid-metal fuels and breeder blankets. R. J. TEITEL, D. H. GURINSKY AND J. S. BRYNER. *Nucleonics*, **12,** 14–15 (*July*, 1954).

Liquid metal reactor fuels and liquid blanket materials, obtained by dissolving U or Th in molten Bi, Pb, Sn or mixtures of these, are discussed. The only satisfactory single phase solution appears to be U in Bi. Dispersions of intermetallic compounds of U or Th with Bi or Sn in liquid Bi, Pb, Sn alloys are also considered, and some of their observed properties are given. L. R. SHEPHERD

539.172.4

11430. Fused salts for removing fission products from U–Bi fuels. D. W. BAREIS, R. H. WISWALL, JR AND W. E. WINSCHE. *Nucleonics*, **12,** 16–19 (*July*, 1954).

The extraction of fission products from liquid U–Bi reactor fuel by treatment with a fused salt is discussed. Experimental results, on the partition of rare earths and uranium between molten Bi and a fused eutectic mixture of KCl and LiCl at 450°C, were in fair agreement with a theory based on the assumption that the rare earth chlorides are formed and dissolve in the fused salt. The uranium remains preponderantly in the Bi. L. R. SHEPHERD

539.172.4

11431. Fuel processing loops; how they are being developed. C. RASEMAN AND J. WEISMAN. *Nucleonics*, **12,** 20–5 (*July*, 1954).

Experimental loops for testing the fused salt extraction process are described. An in-pile loop will circulate liquid U–Bi through the Brookhaven reactor and thence through a fused salt extraction system for continuous processing. Out-of-pile experiments have shown that the presence of oxygen contamination in the loop results in quantitative removal of U from the Bi into the fused salt. Addition of Mg to the metal prevents removal of the U but also inhibits transfer of rare earths. Experiment are in progress to test the effect on the rare earth extraction of adding $MgCl_2$ to the fused salt and Mg to the fuel. L. R. SHEPHERD

539.172.4

11432. A continuously separating breeder blanke using ThF_4. F. T. MILES, R. H. WISWALL, JR, R. J HEUS AND L. P. HATCH. *Nucleonics*, **12,** 26–9 (*July* 1954).

The reactor blanket is in the form of a bed of ThF pellets cooled by a fluorine containing gas. Pa^{23} and U^{233} atoms bred in the blanket diffuse to the surface of the pellets and are fluorinated to PaF_5 and UF_6, both of which are more volatile than the ThF and are consequently carried away by the coolant Experiments have shown that sintering of the ThF pellets seriously increases the time for the U and Pa to diffuse to the surface. A regeneration process of periodic hydrolysis of the blanket to the oxide followed by hydrofluorination reverses the sintering process but introduces serious corrosion problems. L. R. SHEPHERD

539.172.4

11433. Heat exchange in LMF power reactor systems. O. E. DWYER. *Nucleonics*, **12,** 30–9 (*July*, 1954).

Corrosion and erosion problems arising from the use of liquid Bi are outlined very briefly. The evaluation of heat transfer coefficients in liquid metals is discussed. Two possible coolant systems are described, one in which the fuel transfers its heat outside the reactor to a steam generator and to a secondary liquid metal (Na) circuit and the other, an interna cooling arrangement, in which a liquid blanke material is circulated through the core and through a secondary heat exchanger. L. R. SHEPHERD

539.172.4

11434. Finding a container material for the uranium-bismuth fuel system. D. H. GURINSKY, J. E. ATHERTON O. F. KAMMERER, C. KLAMUT, M. SILBERBERG B. TUROVLIN AND J. WEEKS. *Nucleonics*, **12,** 40–2 (*July*, 1954).

Experiments with iron-chromium alloy convection loops and pots containing U–Bi solutions showed that small concentrations of Zr or Mg reduced corrosion and mass transfer. Tracer measurements with Zr^{95} indicated that adsorption of Zr on to the surface of the iron was taking place. It is probable that a monolayer of Zr prevents mass transfer between the container walls and the liquid metal. L. R. SHEPHERD

539.172.4

11435. Direct steam generation for power. S UNTERMYER. *Nucleonics*, **12,** 43–7 (*July*, 1954).

Direct heat transfer from reactor fuel elements to boiling water offers the possibility of higher efficiencies, at lower reactor temperatures and coolant pressures, than in pressurized water-cooled systems with external heat exchangers. Boiling reactors are found to be self-regulating, the formation of steam bubbles causing a reduction in reactivity. The bubbles form in a matter of milliseconds so that the response is very rapid. At pressures of 600 lb/in^2 it is considered possible to generate 40 kW of heat per litre of core. Radioactivity of the steam is slight and of a short period. L. R. SHEPHERD

539.172.4 : 541.15

The problem of dosimetry in the pile. *See Abstr.* 11511

539.172.4 : 621.313.333

11436. The design of totally enclosed mechanical pumps (with particular reference to a 50 h.p. sodium pump). P. Fortescue. *J. nuclear Energy*, **1**, 5–23 (*Aug.*, 1954).

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539.18

11437. Elementary particles. P. E. Hodgson. *Sci. Progr.*, **42**, 599–607 (*Oct.*, 1954).

Summary of present state of knowledge. Gives complete list of phenomenological symbols, distinguishing those which are obsolete.

539.18 : 53

Summer School lectures on mesons. *See Abstr.* 10767

539.18

11438. Two observations of unstable nuclear fragments. P. Ciok, M. Danysz and J. Gierula. *Bull. Acad. Polon. Sci. Cl.* 3, **2**, *No.* 4, 171–4 (1954).

Two more large stars in which a fragment produces a secondary small star were found. Data on the 7 existing events of this type are summarized—they are consistent with the hypothesis of a V_1^0 particle bound in the nuclear fragment. W. J. SWIATECKI

539.18

11439. Nuclear absorption of negative *K* particles. H. DeStaebler, Jr. Letter in *Phys. Rev.*, **95**, 1110–11 (*Aug.* 15, 1954).

An event, which shows a slow V^0-particle and an L-meson coming from the stopping point of a K-particle, and two events showing a slow V_0-particle with no associated L-meson coming from a stopped K-particle, have been observed in the M.I.T. multiplate cloud chamber. They have been interpreted as the nuclear absorption of K-particles, according to the processes: $K^- + n \rightarrow \Lambda^0 + \pi^-$; $K^- + p \rightarrow \Lambda^0 + \pi^0$. P. ROTHWELL

539.18

11440. A new method of measurement of multiple scattering. Application to the study of the disintegration of the μ-meson. C. Mabboux-Stromberg. *Ann. Phys.* [*Paris*] **9**, 441–91 (*July–Aug.*, 1954) *In French.*

The new features described in this thesis concern the measurement of displacements perpendicular to the plane of the emulsion. The necessary accuracy in the setting of the microscope is achieved by coupling a variable capacitance, which is part of an oscillating circuit beating with a quartz oscillator, to the focusing parts of the microscope. A discussion of the experimental and statistical errors is given and optimum conditions are worked out. 42 tracks of μ-e decay electrons were measured by this method and lead to $W = 55\cdot3$ MeV, $\rho = 0\cdot72$ in the formula for the energy spectrum of L. Michel [Abstr. 5677 (1949)]. One abnormal disintegration is attributed to a $\kappa - e$ decay. W. J. SWIATECKI

539.18 : 537.534.79

11441. Possible example of the annihilation of a heavy particle. H. S. Bridge, H. Courant, H. DeStaebler, Jr and B. Rossi. Letter in *Phys. Rev.*, **95**, 1101–3 (*Aug.* 15, 1954).

A photograph of an event in the M.I.T. multiplate cloud chamber shows three electron showers associated with a stopped charged particle. Difficulties in interpreting the event as a decay or an absorption process, lead to the suggestion that it may represent an antiproton or an antihyperon undergoing annihilation with an ordinary proton. P. ROTHWELL

539.18

11442. Positron spectrum from the decay of the μ-meson. R. Sagave, W. F. Dudziak and J. Vedder. Letter in *Phys. Rev.*, **95**, 863–4 (*Aug.* 1, 1954).

This has been studied in detail with a 40 in. spiral-orbit spectrometer. The mesons were created by the 340 MeV deflected proton beam in Be, C and Al targets, and decayed inside the targets. All the data could be best fitted to the theoretical curve with $\rho = 0\cdot23^{+0\cdot03}_{-0\cdot05}$. The masses of the μ-meson and the π^+-meson have been deduced as: $m_\mu = 207 \pm 0\cdot8m_e$, $m_{\pi^+} = 273\cdot4 \pm 1\cdot1m_e$. P. ROTHWELL

539.18 : 778.34 : 537.534.74

Determination of the mass of particles stopping in nuclear emulsions by measurement of multiple scattering. *See Abstr.* 11140

539.18

11443. The analysis of V^0 decays when the errors of measurement are large. J. P. Astbury. *Nuovo Cimento*, **12**, 387–406 (*Sept.*, 1954).

The identification of V^0 decays, starting from the now established Q-values for the Λ^0 and θ^0-particles, is discussed. A method of separating Λ^0 and θ^0-particles is described; it demands measurements only of the negative secondary momentum and of the angle between the secondary tracks. Curves are given which facilitate calculations of Q-values. Since, if the errors of measurement are large, standard errors in Q are unreliable, curves are given by means of which the compatibility of any given event with Λ^0 and θ^0-decay may be checked. The effect of instrumental and selection bias on the interpretation of anomalous V^0 decays is considered. A.

539.18

11444. Measurements of forty-four charged *V*-events. J. S. Buchanan, W. A. Cooper, D. D. Millar and J. A. Newth. *Phil. Mag.*, **45**, 1025–42 (*Oct.*, 1954).

The measurements made on 44 charged V-events are reported and discussed. Arguments are presented to show that most of the events are not the decays of τ- or K_μ-mesons, nor are they "cascade" decays. The simplest explanation of the majority of the events is that they are decays of a heavy meson into a light charged meson and two light neutral particles. From the results of other experiments the charged secondary particles are probably μ-mesons. The primary particle in one event has a mass of at least $(1184 \pm 90)m_e$. This event is discussed in detail. On the assumption that all the events are of the same type, the mean lifetime of the primary particles is found to be greater than 2×10^{-9} sec. Attempts to distinguish a group of particles with a shorter mean lifetime have failed. Twenty-nine of the primary particles are positively charged, thirteen negatively; the signs of two particles cannot be determined. The positive excess is attributed, in the main, to a statistical fluctuation. A.

539.18

11445. Evidence for the β-decay of a *K*-meson. M. W. Friedlander, D. Keefe, M. G. K. Menon and L. van Rossum. *Phil. Mag.*, **45**, 1043–9 (*Oct.*, 1954).

The decay at rest of a *K*-meson in which the secondary particle appears to be an electron of ∼90 MeV has recently been observed. The secondary particle, after traversing a distance of 2·3 cm in the emulsion, appears to have been sharply deviated; thereafter, the track is closely similar to that of a slow electron. The grain density in the track, before and after the deviation, is indistinguishable from the "plateau value." The most plausible explanation of this behaviour is that it is due to the sudden loss of energy of an electron through the production of bremsstrahlung. Alternatively, the secondary particle could be assumed to be (*a*) a π-meson which interacts with a nucleus and undergoes change exchange, the product nucleus subsequently suffering β-decay, or (*b*) a μ-meson which decays in flight. The last two possibilities have been considered and appear very improbable. A.

539.18

11446. π-Meson production in π-nucleon collisions at 1·5 BeV. W. D. Walker, J. Crussard and M. Koshiba. Letter in *Phys. Rev.*, **95**, 852–3 (*Aug.* 1, 1954).

Reactions of the type $\pi^- + p \rightarrow \pi^+ + \pi^- + n$ have been studied and angular distributions of all mesons from this and the reaction $\pi^- + p \rightarrow \pi^- + \pi^\circ + p$ are given for E(meson) > 350 MeV (forward peak) and $E < 350$ MeV (backward peak). Evidence for $\pi^- - n$ interaction occurring on the edge of a nucleus has been found. Statistics of Q values from π^--p events given. W. J. SWIATECKI

539.18

11447. Nucleon polarization resulting from π-meson production. B. T. Feld. *Nuovo Cimento*, **12**, 426–37 (*Sept.*, 1954).

The polarization of the nucleons resulting from the three "fundamental" meson-nucleon reactions $\pi + \mathfrak{N} \rightarrow \mathfrak{N}' + \pi'$, $\gamma + \mathfrak{N} \rightarrow \mathfrak{N}' + \pi'$, $\pi + \mathrm{D} \rightarrow \mathfrak{N} + \mathfrak{N}'$ is derived. It is shown that the observed angular distributions of these reactions permit of two types of solutions—a "Fermi" solution, in which the important interaction is in the meson-nucleon intermediate state of $J = \frac{3}{2}^+$, $T = \frac{3}{2}$; and a "Yang" solution, which requires a strong interaction in the state $J = \frac{1}{2}^+$, $T = \frac{3}{2}$. These solutions can be distinguished on the basis of the polarization of the recoil nucleons. Tables are given for the predicted polarizations in the second and third of the above reactions (the first has previously been discussed by Fermi). The greatest difference between the two solutions is predicted in the photoproduction of neutral mesons. However, the kinematics of the reactions are such that the most likely case for detection of the polarized nucleons is the third of the above reactions; in this case, however, the difference between the predicted polarizations for the two solutions is only in the sign. A.

539.18

11448. Evidence for double production of V^0 particles. R. W. Thompson, J. R. Burwell, R. W. Huggett and C. J. Karzmark. *Phys. Rev.*, **95**, 1576–9 (*Sept.* 15, 1954).

An example of the double production of V^0-particles is described and interpreted as evidence for the process: $\pi^- + p \rightarrow \Lambda^0 + \theta^0$. The Λ^0 and θ^0 are well identified from analysis of their decays in the chamber, from which $Q(\Lambda^0) = 37 \pm 4$ MeV and $Q(\theta^0) = 223 \pm 10$ MeV. The nature of the incident particle is suggested by calculation of its mass from the observed V^0-particle momenta. If the interpretation of the event is correct, the spin of the θ^0 is determined to be integral and the possibility that one of the decay fragments is a muon is excluded, so that $\theta^0 \rightarrow \pi^+ + \pi^-$. A.

539.18

11449. Pion production ratios. II. D. C. Peaslee. *Phys. Rev.*, **95**, 1580–1 (*Sept.* 15, 1954).

For Pt I, see Abstr. 8670 (1954). The ratio of positive to negative pion production is considered for protons of ∼0·35 BeV energy incident on nuclei. The model of a single excited nucleon is used. It is argued that (i) at these energies the meson-producing nucleon state is about equally likely to be $T = \frac{1}{2}$ or $T = \frac{3}{2}$; (ii) structural effects in the final nucleus inhibit π^- production in light nuclei, where isotopic spin is conserved. Effect (ii) may be partly responsible for the observed difference in shape of π^+ and π^- production curves as a function of A. A.

539.18

11450. Production of charged pions from hydrogen and carbon. A. H. Rosenfeld. *Phys. Rev.*, **96**, 130–9 (*Oct.* 1, 1954).

The cross-sections and energy spectra of pions produced in the reactions $p + p \rightarrow \pi^+ + d$ and $p + p \rightarrow \pi^+ + n + p$ have been measured at three angles using 440 MeV protons. Both reactions contribute about equally to the total cross-section. The total cross-section is (4 ± 1) mb and the angular distribution is proportional to $(0{\cdot}15 \pm 0{\cdot}06 + \cos^2 \theta)$. The energy spectra of π^+ and π^- produced in a carbon target at 90° in the laboratory system has also been measured. Results found were $(d\sigma_{\pi^+}/d\Omega) = (0{\cdot}83 \pm 0{\cdot}11)$ mb sterad^{-1} per C nucleus and a π^+/π^- ratio of $7{\cdot}2 \pm 1{\cdot}5$. A.

539.18

11451. Production of pions in nucleon-nucleon collisions at cyclotron energies. A. H. Rosenfeld. *Phys. Rev.*, **96**, 139–49 (*Oct.* 1, 1954).

All available data on the production of pions in nucleon-nucleon collisions at cyclotron energies are compiled and are compared with the phenomenological theory of Watson and Brueckner. The principle of conservation of isotopic spin allows all these cross-sections to be written in terms of only three independent cross-sections, whose excitation functions are predicted by the phenomenological model. The theory represents satisfactorily the excitation functions and the angular distributions that are known experimentally; however, the experimental ratio $\sigma(p + p \rightarrow \pi^+ + n + p)/\sigma(p + p \rightarrow \pi^+ + D)$ appears to be about a factor 2 larger than predicted. Using a notation for total cross-section in which the first subscript indicates the isotopic spin of the initial state, and the second that of the final state of the two nucleons, and expressing all cross-sections in millibarns, then $\sigma_{10}(d) = \sigma(p + p \rightarrow \pi^+ + d) = 0 \cdot 14\eta + 1 \cdot 0$; $\eta^3\sigma_{10}(n + p) = \sigma(p + p \rightarrow \pi^+ + n + p) - \sigma_{11} \simeq 1 \cdot 5\eta^4$; $\sigma_{10} = 2\sigma(n + p \rightarrow \pi^\pm) - \sigma_{11} \lesssim 0 \cdot 3\eta^4$; $\sigma_{11} = \sigma(p + p \rightarrow \pi^0) \simeq 0 \cdot 2\eta^8$: η is the maximum c.m. momentum available to the pion, measured in units of μc. A.

539.18

11452. Meson-proton scattering phase shift analysis. H. A. Bethe and F. de Hoffmann. Letter in *Phys. Rev.*, **95**, 1100–1 (*Aug.* 15, 1954).

The p-phase for $T = \frac{3}{2}$ and s-phases for $T = \frac{3}{2}$ and $\frac{1}{2}$ are re-analysed in the light of recent experimental evidence. G. E. BROWN

539.18

11453. Phase shift analysis of the scattering of negative pions by hydrogen. E. Fermi, N. Metropolis and E. F. Alei. *Phys. Rev.*, **95**, 1581–5 (*Sept.* 15, 1954).

A phase shift analysis of the scattering of negative pions by hydrogen in the range 115 to 215 MeV is presented. In the present paper two solutions are given that represent the data within the experimental error by two rather different sets of phase shifts. One of these solutions is excluded on the basis of some information on the scattering of positive pions. The other solution is compatible with all the experimental data known at present. It is pointed out, however, that this is not the only solution that has such properties. In addition, calculations carried out on scattering of positive and negative pions at 61·5 MeV are presented. A.

539.18

11454. Pion–hydrogen phase shift analysis between 120 and 217 MeV. F. de Hoffmann, N. Metropolis, E. F. Alei and H. A. Bethe. *Phys. Rev.*, **95**, 1586–605 (*Sept.* 15, 1954).

An analysis has been made of the experimental angular distributions of negative pion—hydrogen scattering between 120 and 217 MeV. The usual assumptions of charge independence, and contributions from S and P waves only, are used and the six phase shifts determined as a function of energy by means of the Los Alamos MANIAC. The resulting phase shifts are used to predict positive pion–hydrogen scattering in this energy region. Comparison with the experimental data on positive pions enables one to exclude some of the sets of solutions obtained from the negative pion data. Essentially three acceptable sets of solutions are found. Arguments are given why one of these is likely to be the physically correct one. Its characteristics are that the predominant phase angle with $T = 3/2, j = 3/2$ passes through 90° at about 195 MeV, that none of the other phase angles shows a resonance in the energy region used, and that the $T = 1/2$ phase angles are all small. A.

539.18

11455. Phase-shift analysis of the scattering of negative pions on hydrogen. R. L. Martin. *Phys. Rev.*, **95**, 1606–11 (*Sept.* 15, 1954).

A phase-shift analysis of the scattering of negative pions on hydrogen in the energy range 120 to 217 MeV is presented. The usual assumptions that the scattering is charge-independent and that scattering in S and P states only is important are made and in addition the P-wave phase shifts of isotopic spin $\frac{1}{2}$ assumed to be zero. Of many approximate solutions obtained a solution showing a resonance in the P state of ordinary spin $\frac{3}{2}$ and isotopic spin $\frac{3}{2}$ in the neighbourhood of 195 MeV is considered to have the highest probability of being correct. A.

539.18

11456. Inelastic scattering of 500-MeV negative pions in emulsion nuclei. M. Blau and M. Caulton. *Phys. Rev.*, **96**, 150–60 (*Oct.* 1, 1954).

This has been investigated in 1700 meson-induced events in emulsion nuclei. Large energy losses and strong angular relationships of the emitted mesons have been observed, similar to those in experiments with lower energy mesons. The possible causes for this behaviour are discussed. In 1–3% of the events, production of charged mesons has been found. The cross-section for meson production on free nucleons is estimated to be between 3·5 and 10 mb, considering the possible absorption of one or both mesons. The angular and energy distributions of mesons and recoiling nucleons in events with meson production are discussed. Six events of π^0 production on free protons (or edge nucleons) have been found. The results are compared with observations on meson scattering and meson production in cosmic-ray experiments. A.

539.18

11457. Elastic scattering of 26-MeV negative pions by hydrogen in emulsion. J. Orear, W. Slater, J. J. Lord, S. L. Eilenberg and A. B. Weaver. *Phys. Rev.*, **96**, 174–6 (*Oct.* 1, 1954).

Standard Ilford G5 plates were exposed to a fairly monoenergetic 30 MeV π^--meson beam obtained by slowing down the Chicago 90-MeV beam with absorber and then using magnetic analysis. Range curves were taken indicating a 35% contamination from muons and electrons in this geometry. This figure was independently determined from the grain density distribution of tracks in the emulsion. A flux of $2 \cdot 2 \times 10^5$ tracks per cm^2 was used for area scanning. The average beam energy in the plates is (26 ± 2) MeV as determined from measuring the recoil proton energies in the 5 pion-proton scatterings which were found. An equivalent pion path length of 13×10^4 cm was scanned giving a cross-section of $(1 \cdot 15 \pm 0 \cdot 6)$ mb for the 5 events. This cross-section is for scatterings greater than 50°. Smaller angle scatterings were not considered because of the possibility that such short

recoil protons might be missed by area scanning. Various scanning efficiency checks indicate a scanning efficiency above 90%. The data are analysed to give $(4\cdot7^\circ \pm 2\cdot7^\circ)$ for the phase shift combination $(2\alpha_1 + \alpha_3)$.
A.

539.18
11458. Low-energy behavior of the phase shifts in pion-proton scattering. J. Orear. *Phys. Rev.*, **96,** 176–9 (*Oct.* 1, 1954).

A best fit has been made to all pion-proton scattering phase-shift information under 80 MeV assuming the energy dependence of the phase shifts is momentum to the power $(2l + 1)$ which would be the case for strong short-range interactions. The values obtained for the Fermi-type solutions are $\alpha_{33} = 0\cdot235\eta^3$, $\alpha_3 = -0\cdot11\eta$ and $\alpha_1 = 0\cdot16\eta$. These phase shifts, along with Coulomb forces, fit all scattering experiment data quite closely including the 5 MeV cloud chamber results at Columbia. However, at zero energy they predict $(\alpha_1 - \alpha_3) = 0\cdot27\eta$, while recent photoproduction results and the Panofsky effect as evaluated here predict $(\alpha_1 - \alpha_3) = 0\cdot21\eta$ with rather large uncertainties.
A.

539.185
11459. Milne's problem with capture. J. B. Sykes. *Atomic Energy Res. Establ.* [*Harwell*] *Mem. T*/*M*110, 13 + ii *pp*., figs. (1954).

The variational solution given by Le Caine for Milne's problem with capture is developed as a power series as far as the first power of the parameter $\alpha = l_{\text{tot}}/l_c$. This solution is then transformed to give the solution for a semi-infinite medium with a normal incident current, using the analysis of Placzek and Davison. The application of such solutions to obtain an accurate analysis of observational data for water is discussed.
A.

539.185 : 519.2
11460. Study of the diffusion of neutrons in a sphere of lead by the Monte Carlo method. J. M. Tharrats, J. M. López Roca and V. Herrero Climent. *An. Real Soc. Españ. Fís. Quím.*, **50(A)**, 107–18 (*May–June*, 1954). *In Spanish.*

The Monte-Carlo method has been applied to the study of the diffusion of neutrons emitted by a Ra–Be source in a Pb sphere 7 cm radius. In this way, the primary and secondary spectra of both elastic and inelastic collisions were obtained. The random digits sequence was directly obtained from the 2PA type compound electronic roulette. The study comprises seven hundred and fifty neutrons.
A.

539.185
11461. Total cross sections of liquefied gases for high-energy neutrons. P. Hillman, R. H. Stahl and N. F. Ramsey. *Phys. Rev.*, **96,** 115–20 (*Oct.* 1, 1954).

Total neutron cross-sections of liquid H, He, N, O, A, and several solid elements have been measured at effective energies of 88 ± 2 and 47·5 ± 2 MeV. A liquid scintillation neutron counter was used. Results are in good agreement with previous experiments, where applicable.
A.

539.185
11462. Multiple scattering of neutrons. G. H. Vineyard. *Phys. Rev.*, **96,** 93–8 (*Oct.* 1, 1954).

The theory of multiple scattering of neutrons is developed in cases of interest for diffraction experiments. Computations of second-order scattering for various plane slab sample arrangements are carried out, under a quasi-isotropic cross-section assumption. The relevance of recent computations by Chandrasekhar is pointed out, and these are also applied to the present problem.
A.

539.185 : 513.76
11463. Transformation of scattering cross sections. P. F. Zweifel and H. Hurwitz, Jr. *J. appl. Phys.*, **25,** 1241–5 (*Oct.*, 1954).

A simple method is presented for the calculation of the transformation matrices between the Legendre polynomial expansion coefficients of the scattering cross-section in the laboratory and centre-of-mass systems. Approximate expressions for the matrices are given. Applications to transport problems involving the elastic scattering of neutrons are discussed.
A.

539.185.08
11464. An absolute tissue dosemeter for fast neutrons. G. S. Hurst. *Brit. J. Radiol.*, **27,** 353–7 (*June*, 1954).

It is shown that the Bragg–Gray principle can be applied to proportional counter designs in such a manner that the absolute tissue dose (and hence the flux if the energy spectrum is known) due to fast neutrons can be measured. The method has the combined advantages of high sensitivity to fast neutrons and very low sensitivity to γ-radiation. Two practical designs are described.
A.

539.185.08
11465. Integration of the neutron density in a space by means of point probes. M. A. Vigón and K. Wirtz. *An. Real Soc. Españ. Fís. Quím.*, **50(A)** 155–8 (*July–Aug.*, 1954). *In Spanish.*

A method for the determination of the total neutrons in a moderator medium is described. Results are obtained with one and two measurements for a cubic pile with paraffin with the source placed in the base. These results are compared with those obtained by graphic integration of the density function.
A.

539.185.08
11466. The operation of a thermal neutron time-of-flight spectrometer. P. A. Egelstaff. *J. nuclear Energy*, **1,** 57–75 (*Aug.*, 1954).

A detailed account is given of the various instrumental checks that are carried out with Harwell "slow chopper" neutron spectrometer. A novel source arrangement is described and measurements are presented of the total cross-section of gold and of the velocity spectrum of neutrons in the reactor.
A.

STRUCTURE OF SOLIDS 539.2

539.213 : 532.61 : 539.211
11467. A remark on the determination of surface tension of glass in its solid state. M. Sato. *J. Sci. Res. Inst.* [*Tokyo*] **48,** 1–7 (*March*, 1954).

In connection with Taylor's theory of fracture, a formula to be used for determining the surface tension of solids is proposed, taking the breaking stress into account. As an applicable example of this formula, the surface tension of the Pyrex specimens used by Baker and Preston in their breaking tests is determined to be 152–153 dyn/cm at room temperature, assuming the cases of equal durations of load in dry and wet states. Simultaneously, it is shown that this determining method agrees with that based on Benedicks's theory of lines of force, in spite of different points of view on the mechanism of the wetting effect. A.

539.213.1

11468. Metals in the atomic state in glasses. W. A. Weyl. *J. phys. Chem.*, **57**, 753–7 (*Nov.*, 1953).

Glasses cannot respond to "foreign" ions within their structures in the same fashion as crystalline solids. A glass can neither produce an efficient phosphor when the usual activators (Cu^+, Ag^+, Mn^{2+}, etc.) are incorporated into its structure nor can its properties be changed by minor additions to the same extent as can those of metals or of semiconducting ionic crystals. The reasons for the different responses of vitreous and crystalline matter to "impurities" are explained and examples are cited. The only substances which in concentrations of less than 0·01% can produce strong light absorption for fluorescence in a glass are the metals. The interaction between glasses and metal atoms and the aggregation of metal atoms in glasses as the result of heat treatment or of irradiation are described. A.

539.217

11469. Theory of the diffusion of extraneous atoms in alloys during the process of ordering. II. M. A. Krivoglaz and A. A. Smirnov. *Zh. éksper. teor. Fiz.*, **24**, *No.* 6, 673–80 (1953) *In Russian.*

For Pt I, see Abstr. 10548 (1954). Discusses the problem of the diffusion of atoms inserted into the interstices of a face-centred crystal lattice of binary alloys, e.g. $AuCu_3$, during the disorder-order transition. The temperature- and concentration-dependence of the coefficient of diffusion are investigated for both the ordered and disordered state of the alloy. The effect of the disorder-order transition on the coefficient of diffusion is found to be greater for the face-centred than for the body-centred alloy lattices. F. LACHMAN

539.217

11470. The surface topography of diffusion couples. R. S. Barnes. *Atomic Energy Res. Establ.* [*Harwell*] *Rep. M/R*1396, 10 + v *pp.* (1954).

The free surfaces of diffusion couples have been examined microscopically and with X-rays, and the observed features related to the behaviour of the underlying metal. The voids, which form near to the interface in the faster diffusing metal, produce pits in the surface when they are revealed by the evaporation of the metals, which occurs during the anneal. Within the diffusion zone surface steps occur at grain boundaries, and the surfaces of the grains are rippled. Rippling in copper/nickel couples has been studied in detail, and the line of the ripples found to correspond to the intersection with the surface, of a {110} plane in the grain. It is suggested that the ripples are caused, on the nickel-rich side of the interface, by the insertion of a series of adjacent parallel {110} atomic planes and, on the copper-rich side, by the elimination of a similar series of planes. The edge dislocation configuration, already proposed [Abstr. 6791 (1952)], could produce such an effect when in the presence of a non-equilibrium number of atomic defects, such as occurs during intermetallic diffusion. A.

539.217

11471. Electrostatic energy calculations for sodium tungsten bronze (Na_xWO_3). J. F. Smith. *Phys. Rev.*, **95**, 1369–73 (*Sept.* 15, 1954).

Recent measurements of the activation energy for diffusion of sodium in the metallic sodium tungsten bronze, $Na_{0\cdot78}WO_3$, gave a value of 51·8 kcal/mole. To determine whether ionic bonding could be responsible for this high activation energy, electrostatic energy calculations have been made. Calculated activation energies for sodium diffusion using a model with random sodium distribution do not agree well with the measured value, but this discrepancy may be because of the consideration of ions as point charges which must be a poor approximation at small interionic distances. Further calculations of the total electrostatic energy as a function of sodium concentration have been made on the basis of random sodium distribution, point charges of Na^+, W^{+6}, and O^{-2}, and a uniform neutralizing charge of free electrons. These calculations indicate that cubic sodium tungsten bronze should be unstable or metastable below $x = 0\cdot35$. This calculated value of sodium concentration is in good agreement with the known phase transition occurring at a sodium concentration between $x = 0\cdot30$ and $x = 0\cdot38$. A.

539.217

11472. Mobility of impurity ions in germanium and silicon. C. S. Fuller and J. C. Severiens. *Phys. Rev.*, **96**, 21–4 (*Oct.* 1, 1954).

Lithium has been shown to migrate as a singly-charged positive ion in single crystals of both Ge and Si in temperature ranges of 150–600°c and 360–860°c, respectively. The mobility of the Li^+ in crystalline Ge and Si has been measured as a function of temperature. Through the use of the Einstein relation between diffusion constant and mobility, values of the diffusion constants in cm²/sec of Li^+ in Ge and Si are obtained as follows: $D = 25 \times 10^{-4} \exp[(-11\,800)/RT]$ for Ge and $D = 23 \times 10^{-4} \exp[(-15\,200)/RT]$ for Si, in satisfactory agreement with previously published results on the thermal diffusion of Li^+. A curious reversion of conductivity type of solid solutions of Li in Ge is discussed. Copper has likewise been found to move as a positive ion in germanium in the temperature range 800–900°c leading to diffusivities in agreement with previously published results. A.

539.23 : 535.343.2–15

11473. Determination of the structure of oriented Terylene film using polarized infra-red radiation. R. G. J. Miller and H. A. Willis. *Trans Faraday Soc.*, **49**, 433–41 (*April*, 1953).

The infrared absorption spectrum of Terylene from 5–15 μ has been interpreted in detail by assignment of the absorption bands to atomic groups in the molecule. By the use of polarized infrared radiation the dichroism on these absorption bands has been

used to determine the orientation of the molecules in cold-drawn Terylene film. It is concluded that not only is the chain direction parallel to the direction of drawing, but also the plane of the molecules is approximately perpendicular to the plane of the film.
A.

539.23 : 666

11474. Study of metal film on glass surface. B. K. Banerjee. *Proc. Nat. Inst. Sci. India*, **20**, 241–4 (*May–June*, 1954).

The nature of the adherent film of different metals such as Au, Ag and Cu deposited by chemical method as well as by the pyrolysis method, has been studied, and in that connection the size of the metal composing the film has been determined. Further, the effect of temperature on the nature of the film has also been investigated. It has been found that the size of the particle composing the film is of colloidal dimension and with temperature treatment, the metallic reflection of the film diminishes considerably and ultimately a transparent glass is formed having a distinct coloration different from the original specimen. The vitreous characteristic of the specimen is retained in the case of Au and Ag after heat-treatment, whereas in the case of Cu the partial devitrification of the glassy matrix takes place.
A.

539.26

11475. An X-ray microbeam study of polycrystalline specimens of aluminium and iron deformed in tension. A. Kelly. *Acta cryst.*, **7**, 554–8 (*Sept.*, 1954).

Polycrystalline specimens of pure aluminium and of iron have been examined with the X-ray microbeam technique at various stages of a tensile test. From the X-ray photographs, measurements have been made of the size of the particles formed within the grains during deformation, of the breadths of the X-ray reflections from these crystallites and of the mean angle between them. The particles are identified with the regions between slip bands in the material and an attempt is made to account for the stress–strain curve of the specimens from this hypothesis and the results of a dislocation theory due to Frank. Reasonable agreement is found between calculation and experiment.
A.

539.26 : 539.4.016.2

11476. Study of cold-working by microfocussing X-ray. I. Fine structure of Laue spot. T. Sutoki and K. Nakajima. *Sci. Rep. Res. Insts Tôhoku Univ. A*, **6**, 244–52 (*June*, 1954).

By successively cold-working and annealing aluminium single crystals made from the melt, the changes in Laue spots were observed by ordinary and microfocusing X-rays. It was found that with the repetition of working and annealing, the fine structure of the Laue spots from the operative slip plane grew complicated, depending on the temperature of annealing. In the case of low temperature annealing, the lamellar structure of the spot remained stable, while in the case of high temperature annealing it changed into an irregular, complicated structure incapable of being resolved with the present apparatus.
A.

539.26 : 548.736 : 545.824

Standard X-ray diffraction powder patterns. *See Abstr.* 11523

539.27

11477. An electron-diffraction examination of thin films of lithium fluoride and copper prepared by vacuum evaporation. J. S. Halliday, T. B. Rymer and K. H. R. Wright. *Proc. Roy. Soc. A*, **225**, 548–63 (*Sept.* 22, 1954).

From accurate measurements of the interplanar spacings, the stresses in the specimens have been determined. Lithium fluoride specimens consist of long cylinders (diameter ∼100 Å) having their axes perpendicular to the substrate, there being no fixed relation between the axis of a cylinder and the crystallographic axes, apart from a slight tendency for the [100] crystal axis to lie along the axis of the cylinder. A surface tension of the order of −1000 dyn/cm acts over the surface of each crystal. Copper specimens consist of crystallites in the form of disks (diameter ∼90 Å, thickness ∼15 Å) parallel to (111) planes. Stresses exist in the specimen due to superficial oxidation of the specimen as a whole, not of the individual crystallites.
A.

539.27

11478. Low-energy electron diffraction investigation of chemisorbed gases on the (100) faces of copper and nickel single crystals. R. E. Schlier and H. E. Farnsworth. *J. appl. Phys.*, **25**, 1333–6 (*Oct.*, 1954).

The use of low-energy (10–250 eV) electron diffraction as a method of studying the chemisorption of gases on metal single crystals is described. The apparatus permits controlling the temperature of the crystal in the range from liquid nitrogen to room temperatures during observation. Outgassing the crystal is effected by strong heating using electron bombardment. The residual gas structures on the (100) faces of copper and nickel single crystals are determined to be: (1) a monolayer with a single-spaced square array, found on both copper and nickel after heating at temperatures slightly below the minimum temperature for observable evaporation and (2) a double-spaced, face-centred square array found after heating at or above this temperature. Nitrogen adsorbs on the (100) face of a copper single crystal at 25°c and −78°c into an incomplete single-spaced square array. Most of the adsorption at 25°c occurs in a pressure range of 10^{-4} to 10^{-1} mm Hg in a ten-minute interval, with little change occurring between 10^{-1} and 8 mm Hg. At −78°c the corresponding pressure range is 10^{-4} to 10^{-3} mm Hg with little adsorption occurring between 10^{-3} and 1 mm. At room temperature, oxygen adsorbs into a complete, single-spaced, square array at a pressure of 2×10^{-3} mm Hg in a ten-minute interval. At higher pressures, additional oxygen adsorbs into a thicker layer of no regular structure.
A.

539.27

11479. A method of examining selected areas of surfaces using replicas and the electron microscope. G. R. Booker. *Brit. J. appl. Phys.*, **5**, 349–50 (*Oct.*, 1954).

A simple method has been devised using wet-stripped replicas. The selected area of the surface is identified by fine scratches in the immediate vicinity. The corresponding portion of a replica is mounted over a 0·015 in. diameter hole in a copper disk and viewed in an electron microscope operating with a specimen screening aperture. The method has several advantages over methods hitherto used, e.g. it has extremely wide application as it does not depend on surface structure for identification, the positioning of the replica on the copper disk is rapid and can be correctly performed each time, and an uninterrupted area of 0·015 in. diameter can be observed. A.

ELASTICITY . STRENGTH . RHEOLOGY
539.3/.8

539.3

11480. Compression wave velocity experiments with copper. J. Savitt, R. H. Stresau and L. E. Starr. *J. appl. Phys.*, **25**, 1302–10 (*Oct.*, 1954).

A method for obtaining experimental compression wave velocities in metals is described. Measurements of the compression wave velocity in copper were made and found to be in good agreement with theoretical predictions. It is suggested that the discrepancy between the velocity (4730 m/sec) reported herein and that reported by Rinehart and Pearson (3600 m/sec) is associated with the different geometries of the two sets of experiments. A.

539.313

11481. Load-deflexion relations of rubber bush mountings. J. E. Adkins and A. N. Gent. *Brit. J. appl. Phys.*, **5**, 354–8 (*Oct.*, 1954).

The relation between applied force and deflection for bonded cylindrical rubber bush mountings of various dimensions is investigated theoretically and experimentally for four principal modes of deflection. For symmetrical deformations of the elastic material, a theoretical treatment based on the classical linear theory of elasticity is found to predict adequately the variation of stiffness with bush length. In the case of unsymmetrical deflections the theoretical treatment is limited to the derivation of approximate values for the limiting stiffness for long and short bushes. These theoretical values of limiting stiffness are compared with the values measured experimentally. A.

539.32

11482. A study of the impact of spheres on plates. J. P. A. Tillett. *Proc. Phys. Soc.* [*London*] *B*, **67**, 677–88 (*Sept.*, 1954).

Measurements of the coefficient of restitution have been made for the impact of steel balls on plates of glass and plastics. The times of contact have also been measured. The coefficient of restitution is found to be a function of the size of the specimen as well as of its elastic and anelastic properties. The variation in the value of the coefficient with the thickness of the specimen is in agreement with the theoretical variation derived by Zener. The value of the method of rebounding balls for an investigation of the anelastic properties of materials is discussed. A.

539.32

11483. Internal friction and dynamic modulus of cold-worked metals. A. S. Nowick. *J. appl. Phys.*, **25**, 1129–34 (*Sept.*, 1954).

The complexities of the internal friction and dynamic modulus of metals in the cold worked condition may be understood reasonably well by separation of the phenomena into the following three distinct effects: (1) the "nonlinear" effect, characterized by strong amplitude dependence, frequency independence and its disappearance after severe deformation; (2) the Köster effect, which shows rapid recovery after deformation, at temperatures well below the recrystallization temperature; (3) the "viscosity" effect, characterized by strong frequency and temperature dependence. The origin of each of these effects is briefly discussed from the point of view of dislocation theory. A.

539.32 : 541.64

11484. Effect of crystallinity on the dynamic mechanical properties of polyethylenes. L. E. Nielsen. *J. appl. Phys.*, **25**, 1209–12 (*Oct.*, 1954).

Six polyethylenes which differed widely in the degree of crystallinity were studied. The crystallinity was determined from density measurements. Both the density and the dynamic mechanical measurements were made over the temperature range from 25°c to above the melting point of the material. The dynamic shear modulus drops rapidly as the melting point is approached. The mechanical damping goes through a maximum near 60°c and then through a minimum just below the melting point. It is possible to predict the density of any of the polyethylenes at any temperature below the melting point from the value of the shear modulus at the same temperature. The more crystalline materials have the higher shear moduli and the higher melting points. A.

539.434

11485. The creep of aluminium during neutron irradiation. E. R. W. Jones, W. Munro and N. H. Hancock. *J. nuclear Energy*, **1**, 76–86 (*Aug.*, 1954).

A new method of measuring creep, suitable for use in a pile, has been developed, and one experiment on 99·8% aluminium has been done in the N.R.X. pile at Chalk River, Canada. It has been shown that the creep rate is not significantly increased in a flux of $1\cdot3\times10^{12}$ fast and 6×10^{12} thermal neutrons. A.

539.501

11486. Composition of apparent shearing forces during shear degradation of polymers. A. B. Bestul. *J. appl. Phys.*, **25**, 1069–74 (*Sept.*, 1954).

An investigation has been made of the degradation of Vistanex polyisobutenes having viscosity-average molecular weights from about 500 000 to 2 500 000 by shearing in solution in cetane at polymer concentrations from 5 to 20 wt %, at nominal rates of shear from 9000 to 66 000 $\sec^{-1}$, and at temperatures from 20° to 80°c. The initial apparent shearing loads, observed at the beginning of the degradation process, vary in unexpected ways with variations in nominal rate of shear, temperature, concentration, and initial molecular weight of the polymer. In some cases the observed variations are opposite to those which would be expected on the basis of viscoelastic resistance to shearing. These results can be explained on the basis of the hypothesis that the observed apparent shearing forces include some contribution associated with the energy used up in breaking chemical bonds in the polymer molecules during the degradation process. If this hypothesis is correct, valid viscosity values cannot be obtained directly from observed apparent shearing forces in viscometry measurements under conditions where shear degradation occurs. A.

539.501

11487. Relaxation time spectrum of dough and the influence of temperature, rest, and water content. J. R. Cunningham and I. Hlynka. *J. appl. Phys.*, **25**, 1075–81 (*Sept.*, 1954).

The effect of temperature, rest period and water content on stress relaxation in doughs held at constant extension has been studied with a relaxometer previously described. Temperature was varied from 13 to 35°C, rest period from 2 to 120 min and water content from 74·4% to 86·0% dry basis. It is found that the shape of the relaxation curves on a log time plot does not change with temperature in the above range but that the curve is shifted laterally along the log time axis. This permits the construction of master curves valid in the temperature range and extends the time scale of observation. The long relaxation time end of the distribution of relaxation times is affected most by rest period, decreasing as rest period is increased, and the short time end increases as water content is decreased. Activation energies from 11 to 24 kcal per mole are calculated for relaxation from the shift of the curve on the log time axis. There is an indication that the activation energy depends on temperature and increases with rest period. A mathematical framework, based on the general Maxwell model, is discussed and the distribution function on the log time axis is interpreted in terms of viscosity and modulus of the relaxing mechanisms. Special reference is made to the "box distribution" and a viscosity is calculated. A.

539.501

11488. Constant stress elongation of soft polymers: plasticizer studies. M. R. Hatfield and G. B. Rathmann. *J. appl. Phys.*, **25**, 1082–5 (*Sept.*, 1954).

Constant stress measurements have been made on lightly cross linked GR-S and polyisobutylene of 7 million molecular weight. The modulus values as a function of temperature, time and concentration of mineral oil plasticizer have been treated according to the "reduced variables" principles. Since both plasticized and unplasticized samples showed the expected equivalence of temperature and time, the modulus values could be shifted to produce master curves for each composition. In the case of GR-S the concentration of plasticizer could be similarly reduced to yield a single curve for all the data. The polyisobutylene results, however, showed quite clearly that the plasticizer had a unique effect not paralleled by temperature or time. This effect has been attributed to the pseudoequilibrium modulus which apparently results from chain entanglements. Since the pseudoequilibrium modulus should be proportional to the number of chain entanglements per gram of polymer, it should vary as the square of the volume fraction of polymer. It is shown that a correction of this type improves the shift of the curves for polyisobutylene. Changes in activation energy with the addition of plasticizer are apparently within experimental error (± 2 kcal) in all cases. A.

539.50

11489. Some rheological properties of concentrated polyisobutylene solutions. F. J. Padden and T. W. DeWitt. *J. appl. Phys.*, **25**, 1086–91 (*Sept.*, 1954).

Three types of measurements have been made on concentrated polyisobutylene solutions. Dynamic measurements have been extended to low frequencies and the dynamic viscosities and rigidities determined in the region close to that in which pure viscous flow predominates. A modified Stormer viscometer has been used to determine the apparent (non-Newtonian) viscosities of the same solutions. Pressures developed (normal stress) at the inner cylinder have also been measured in a concentric cylinder apparatus with the inner cylinder rotating. It is noted that superposition procedures currently used for dynamic data are apparently applicable to the viscosity and pressure data with the rate of shear taking the place of frequency. Relations between these phenomena are discussed in the light of a theory proposed by one of the authors. A.

539.501

11490. The rheological unit in raw elastomers. M. Mooney and W. E. Wolstenholme. *J. appl. Phys.*, **25**, 1098–101 (*Sept.*, 1954).

Reasons are adduced for suspecting that in a raw elastomer subjected to continuous shear there exist groups of molecules which are held together by entanglement or by thixotropic attachments and move and rotate essentially as elastic solid bodies. Such coherent molecular groups are called rheological units. If an elastomer in continuous shear consists essentially of closely-packed rheological units, such units, rolling on each other, will transfer a rubber soluble dye across the shear planes as the ink rollers transfer ink in a printing press. This predicted phenomena has been observed with a Mooney viscometer fitted with a smooth rotor, the face of which is covered with a thin film of dried cement containing a dye in high concentration. From the velocity of the colour front a rough value can be computed for the mean diameter of the rheological units. The diameters for a series of different elastomers lie in the range from 1 to 35 μ. A.

539.501

11491. Further dynamic investigations on polymers. W. Philippoff. *J. appl. Phys.*, **25**, 1102–7 (*Sept.*, 1954).

Using the vibration tester of the Franklin Institute, a check of the proportionality between stress and strain in dynamic testing disclosed that a proportionality exists when heating is eliminated. A comparison of values of the dynamic test and steady-state experiment in the same range of rates of shear and shearing stress showed that the behaviour is basically different; whereas in the dynamic test the viscosity is independent of both amplitude and shearing stress, in the steady-state test experiment a very high dependence exists. The curve of viscosity *v.* rate of shear (D) is very similar to the one of dynamic viscosity *v.* frequency (f). A frequency shift of the order of two is involved in comparing D and f. The application of Ferry's method of reduced variables to a polyisobutylene solution, liquid polyesters and solid plastics showed its validity. A precision test on the polyester showed that the temperature shift, $T_\rho/T_{0\rho_0}$, is necessary to make experimental values at different temperatures fit. The reduced curve of G' *v.* frequency for different plastics has an S shape with different slopes in a very wide range of frequency around 10^{24}. A.

539.501

11492. Stress and strain. Discussion of Dr. Philippoff's paper. W. F. G. SWANN. *J. appl. Phys.*, **25**, 1108–9 (*Sept.*, 1954).

See preceding abstract.

539.501

11493. Rotational plastometry applied to molten polyethylene. F. D. DEXTER. *J. appl. Phys.*, **25**, 1124–9 (*Sept.*, 1954).

A concentric cylinder rotational plastometer which automatically plots the shear strain *v.* time curve for each of a number of shear stresses is described. The flow behaviour of molten polyethylene resins, measured with this instrument from 130°C to 210°C, is discussed. It is shown that, at each shear stress, the shear strain *v.* time curve for these resins is describable in terms of a viscosity, an elastic shear strain and a retardation time. As the shear stress is raised both the viscosity and retardation time decrease, while the elastic shear strain increases. The shear stress dependency of the viscosity and elastic shear strain are shown to be related and in a manner which suggests that the viscosity change is the result of an entropy effect. A.

539.531 : 538.221 : 621.317.49

11494. Magnetic measurement of mechanical hardness. D. HADFIELD. *Proc. Instn Elect. Engrs II*, **101**, 529–34 (*Oct.*, 1954).

For abstract, see Abstr. 1798 (1954).

539.61

11495. Frictional adhesion of metal to glass, quartz, and ceramic surfaces. R. B. BELSER. *Rev. sci. Instrum.*, **25**, 862–4 (*Sept.*, 1954).

In 1947 Wooster and McDonald reported that titanium by frictional contact would adhere to glass, certain mineral and ceramic surfaces. In order to explore this property further small disks of a number of different metals, mounted separately on one-eighth-inch shafts driven by a high-speed hand-grinder, were applied to glass, quartz and ceramic surfaces. By suitably varying the rev/min of the motor and the pressure of application, the metal of the disks could be made to adhere securely to such surfaces. At higher rev/min erosion of the glass surfaces usually occurred. Variations of the technique of application allowed either the metallic coating or the cutting of glass. Some of the metals tested were titanium, zirconium, aluminium, magnesium, gold, silver, copper, iron, nickel, cobalt, cadmium, zinc and lead. A.

PHYSICAL CHEMISTRY 541

PHASE EQUILIBRIUM. CHEMICAL REACTIONS 541.11/.12

541.124

11496. Studies on the discharge reaction in liquid air. III. On the mechanisms of nitric oxide- and ozone-formation. Y. NOMURA. *Sci. Rep. Res. Insts Tôhoku Univ. A*, **6**, 147–58 (*April*, 1954).

For Pt II, see Abstr. 6069 (1954). The emission spectra and the current-wave forms were obtained from the discharge in liquid oxygen, liquid nitrogen and liquid air. From the results obtained, the mechanisms of NO- and ozone-formation were discussed. It was concluded that NO- was produced by the reaction between $N_2(B^3\Pi_g)$ and O_2 (ground), and that ozone was formed by the reaction between O (ground) and O_2 (ground) at a very early stage of the spark discharge characterized by the emission of the continuous spectrum, being hardly formed through the exothermic arc discharge. A.

541.124

11497. Decomposition of methanol induced by methoxy radicals. Y. TAKEZAKI AND C. TAKEUCHI. *J. chem. Phys.*, **22**, 1527–34 (*Sept.*, 1954).

Kinetical studies were made at 167°C on the decomposition of methanol induced by methoxy radicals, by pyrolysing a small amount of dimethyl peroxide in methanol. A considerable amount of ethylene glycol was found. A mechanism was proposed, and the kinetical equations derived therefrom could express the greater part of the reaction quantitatively. The dissociation rate constant of dimethyl peroxide is represented by $4{\cdot}1\times10^{15}\exp(-36{\cdot}9\ \text{kcal}/RT)\ \text{sec}^{-1}$. A.

541.127

11498. Ion-pair yield of the tritium–oxygen reaction. L. M. DORFMAN AND B. A. HEMMER. *J. chem. Phys.*, **22**, 1555–8 (*Sept.*, 1954).

The rate of reaction of tritium and oxygen, initiated by the tritium β-radiation, has been investigated at 25°C, in the absence of mercury vapour, by using a sensitive Bourdon gauge as the manometer. The rate is not linear with time, but shows a small continual decrease as the reaction proceeds. The initial reaction rate was found to be directly proportional to the tritium pressure, and hence proportional to the radiation intensity. It was independent of the oxygen concentration over the range investigated. The reaction rate shows a slight dependence on the isotopic composition of the hydrogen reactant, tending to rise with increase in the mole fraction of protium. The initial reaction rate may be represented by $R_0 = 1{\cdot}19\times10^{-4}C_{T_2}(1+0{\cdot}3m_H)$, where C_{T_2} is the tritium concentration in moles/litre or other absolute concentration units, and, m_H is the mole fraction of protium in the hydrogen reactant. On the basis of a requirement of 33 eV per ion pair in the reactant mixture, the initial ion-pair yield for tritium disappearance or water formation is $(M/N)_0 = 3{\cdot}2_5$ for the reaction of pure tritium with oxygen. Material balance measurements indicate that little or no peroxide appears in the product. A.

541.127

11499. Theory of the spherical diffusion flame: the effect of atmosphere depletion. F. T. SMITH. *J. chem. Phys.*, **22**, 1605–9 (*Sept.*, 1954).

A major uncertainty in the interpretation of data from spherical diffusion flame methods of measuring reaction rates has lain in the difficulty of estimating the effect of depletion of the atmosphere reactant. It is known that the exact treatment of this problem, assuming spherical, purely diffusive flow, leads to a non-linear ordinary differential equation of the second order. An analytical solution of this equation is presented in a form conveniently applicable to experimental data. The correction is shown to depend on a parameter which is usually small. The solution is applied to the method of temperature pattern measurements, and a modified method of calculating rate constants from experimental data is proposed. The correction to the reaction rate constants previously determined by this method is shown to be small. The use of a wider range of experimental variables than heretofore is made possible. A.

ELECTROCHEMISTRY 541.13

541.135.5

11500. Transient response of the glass electrode to pH step variations. A. DISTÈCHE AND M. DUBUISSON. *Rev. sci. Instrum.*, **25**, 869–75 (*Sept.*, 1954).

A d.c. amplifier with electrometer input stage is described making it possible to display pH changes on the oscilloscope screen for physiological applications. Sensitivity is 0·003 pH unit per cm beam deflection; noise 50 μV; drift 300 μV/hr ($\simeq$0·005 pH unit). A simple hydraulic mechanism is used to produce very fast pH steps under the electrode. The speed of the electrode response is shown to tend towards a finite limit when the speed of the pH change increases. The form of the transient in the fastest records is close to an exponential curve $e^{-\alpha t}$, with $1/\alpha \simeq 30$ msec. The response is independent of the membrane thickness (5 to 10 μ). Some evidence exists to show that the response of the electrode to pH steps is analogous to the response of a low-pass RC-filter to a corresponding voltage step, where R and C are, respectively, the resistance and the capacity of the glass membrane. R and C values determined from the analysis of the electrode response to step voltages in series give $RC \simeq 30$ msec in agreement with the experimental results. A.

541.135.5 : 620.193 : 621.317.79

11501. A potentiostat for corrosion study. M. H. ROBERTS. *Brit. J. appl. Phys.*, **5**, 351–2 (*Oct.*, 1954).

The potential difference between a standard electrode and a test electrode in an electrolytic cell forms the input to a thermionic d.c. amplifier. The output current of the amplifier flows between the test electrode and a third electrode of platinum. Any change in potential of the test electrode alters the output current to reduce the charge, the system forming a closed-loop proportional controller. The two-stage amplifier is symmetrical, so that zero or reverse current can be obtained without loss of sensitivity. 20 mA output can be supplied with less than 100 mV variation of electrode potential. A.

PHOTOCHEMISTRY . RADIATION CHEMISTRY 541.14/.15

541.1

11502. Actinometry of ionizing radiation. N. MILLER AND J. WILKINSON. *Disc. Faraday Soc.*, *No.* 12, 50–60 (1952).

A number of systems which have recently been proposed for the chemical dosimetry of ionizing radiation are compared and criticized, the object being to review the present position and assist others who may be considering the use of these methods. A.

541.1

11503. Chemical phenomena in irradiated pure water. P. BONET-MAURY. *Disc. Faraday Soc.*, *No.* 12, 72–9 (1952).

Densely ionizing radiations (natural α-particles) decompose water, following a simple mechanism in which secondary reactions interfere only to a small extent. The action of sparsely ionizing radiation on water, for example X-rays, leads to a very small radiolysis. Dynamic equilibria between the formation and decomposition of products are observed and establish an equilibrium concentration, independent of dose, within certain limits. The heavy accelerated particles behave as if they contained an X-ray and an α-particle component; the radicals of the X-ray component can react with the H_2O_2 or H_2 from the α-component and this picture is perhaps applicable to all ionizing particles. For a linear ion density of the order of 200 ion pairs/μ (corresponding to the equidistance of the radicals H and OH) the yield per particle passes through a maximum and this critical density appears to mark the transition of the α-particle chemistry to the X-ray chemistry. The radiochemical reactions depend without doubt on the initial distribution of ionization in the water, no matter what the ionizing particle is, and this fact plays a major part in the chemistry of radiations. The numerous biological effects depend in the same manner on the ion density and the different biological efficacy of certain radiations can be explained by the difference in the primary chemical effects. A.

541.15

11504. Mechanism of decomposition of water by ionizing radiations. A. O. ALLEN. *Disc. Faraday Soc.*, *No.* 12, 79–87 (1952).

Irradiated water undergoes a decomposition to molecular H_2 and H_2O_2, simultaneously with the decomposition to free radicals, H and OH. With γ-rays or hard X-rays, the yield of the molecular decomposition is about 0·6 H_2 molecules formed per 100 eV absorbed, and the yield of free radicals appears to be about 3·5 radical pairs per 100 eV. As the ionization density of the radiation is increased, the molecular yield increases and the free radical yield falls. The decomposition of pure water reverses itself because the free radicals initiate a back reaction between the decomposition products. The rate of the back reaction increases with increasing concentration of dissolved hydrogen but decreases with increasing concentration of dissolved oxygen or hydrogen peroxide. This unusual type of kinetics leads to some peculiar phenomena in water radiolysis. The molecular decomposition is ascribed to reactions occurring in the very small regions of high energy density along the charged particle track (hot spots) which correspond to the "ion clusters" formed by fast particles in a gas. A.

541.15

11505. Decomposition of potassium iodide solution by ultrasonic waves. S. Parthasarathy, N. N. Bakhshi and M. Pancholy. Letter in *J. sci. industr. Res.*, **13B**, 370–1 (*May*, 1954).

Although the amount of iodine liberated by the action of the waves increases with increasing concentration of iodide the ratio of iodine liberated to iodide concentration decreases. W. GOOD

541.15

11506. Chemical consequences of the (*n*, γ) reaction on platinum complexes. B. C. Haldar. *J. Amer. Chem. Soc.*, **76**, 4229–33 (*Aug.* 20, 1954).

The 18-hour platinum activity is found distributed in three different fractions: (1) the original compound or its derivative, (2) anions removable by ion-exchange resins IRA-400 and IR-4B, (3) cations and neutral molecules different from the original compound. The retention of activity in complexes with bidentate groups varies from 4 to 7% and is less than that in complexes with monodentate groups. From the retentivity values it appears that two or more bonds are broken in 93 to 96% of the cases. A detailed analysis of the products from slow neutron bombardment of $[Pt(en)_2]Cl_2$ indicates that removable anion activity exists in three different forms—the first form (9%) extractable into butyl acetate from 6 N HCl without addition of stannous chloride, the second form (25%) extractable into butyl acetate only after addition of stannous chloride and the third form (15%) removable from solution only by anion exchange resins. It is observed that oxidation of bivalent to tetravalent platinum takes place as a result of the capture process. Of all the compounds studied in the present investigation, *trans*-$[Pt(en)_2$–$Cl_2]Cl_2$ seems to be most suitable for the preparation of high specific activity radioplatinum by the (*n*, γ) process. A.

541.15

11507. Properties of irradiated polyethylene. Effect of initial molecular weight. E. J. Lawton, J. S. Balwit and A. M. Bueche. *Industr. Engng Chem.*, **46**, 1703–9 (*Aug.*, 1954).

Cross-linking of polyethylene when irradiated with high energy electrons has been previously reported [Abstr. 7254 (1953)]. The experiments described here were undertaken to determine the effect of initial molecular weight on the amount of radiation required for cross-linking and to determine the effect of irradiation on some of the physical properties. A.

541.15

11508. Absolute yield of the ferrous sulfate oxidation reaction. J. Weiss, W. Bernstein and J. B. H. Kuper. *J. chem. Phys.*, **22**, 1593–6 (*Sept.*, 1954).

The absolute yield of the ferrous sulphate oxidation reaction, under the influence of ionizing radiation, has been determined. A polystyrene, parallel plate ionization chamber, filled with argon, nitrogen or air, was used to measure the energy absorbed per unit volume of the solution through the application of the Bragg–Gray principle. The ionization current was extrapolated to zero changer spacing. In related experiments the average ionization potential of polystyrene was determined to be approximately 61·0 V; the value of *W* for air for electrons was determined to be 34·3 eV by comparison with argon and nitrogen. The *G* value obtained in this experiment using the three gases was 15·9 ± 0·5 ions/100 eV, in good agreement with calorimetric and cathode-ray bombardment measurements. A.

541.15

11509. The pile irradiation of polyethylene. M. Dole, C. D. Keeling and D. G. Rose. *J. Amer. Chem. Soc.*, **76**, 4304–11 (*Sept.* 5, 1954).

Polyethylene in the form of films and granules was irradiated in the heavy water pile of the Argonne National Laboratory, both in a vacuum and in the presence of air. The composition of the evolved gas, stress–strain relations and tensile strength were determined for one period of irradiation. Bromine absorption, infrared absorption spectra, extent of gel formation and viscosity of solutions were measured as a function of the duration of irradiation. The most detailed studies were made of the vacuum irradiated samples. The first noticeable change in the composition of the film was the disappearance of the vinylidene group as hydrogen was evolved. This decrease in unsaturation was more than compensated for by the formation of the vinylene group. The bromine absorption studies demonstrated that 70 to 80% of the hydrogen evolution produced unsaturation, the remaining 20 to 30% cross linkages. From the composition of the evolved gas, it was estimated that C–C bonds along the side chains were ruptured about half as frequently as C–H bonds, but much more frequently than C–C bonds along the main hydrocarbon chain. The viscosity average molecular weight of the soluble fraction at first increased slightly, but then decreased to one-third its original value. The cross-linking produced marked changes in the stress–strain characteristics without, however, greatly affecting the tensile strength when the irradiation was carried out in a vacuum. A postulate of long range migration of chemically active centres is proposed to explain the initial rapid decrease in the vinylidene concentration. A.

541.15

11510. Gamma-ray induced oxidation of aqueous formic acid–oxygen solutions. Effects of oxygen and formic acid concentrations. E. J. Hart. *J. Amer. Chem. Soc.*, **76**, 4312–15 (*Sept.* 5, 1954).

Radiation yields of carbon dioxide, hydrogen and hydrogen peroxide formed and oxygen reacted have been measured over the formic acid concentration range 0·0001 to 1·0 M and the oxygen concentration range 0·005 to 1·2 mM. In the range 0·005 to 0·05 M formic acid, the reaction kinetics are fairly simple, and a ratio of rate constants of 540 for $k_{(H+O_2)}/k_{(H+HCOOH)}$ is found. At higher formic acid concentrations there is evidence that formic acid is competing with water for the capture of electrons ejected from the water. The results are interpreted in terms of radical pair and molecular product yields of the γ-rays. A.

541.15 : 539.172.4

11511. The problem of dosimetry in the pile. J. Wright. *Disc. Faraday Soc., No.* 12, 60–72 (1952).

Since energy absorption from pile radiation is high enough for calorimetric measurement at reasonable pile powers, such measurements when complete should provide a basis of dosimetry for pile radiation chemistry. Monitors are required for each individual irradiation so that the dose can be related to that received in unit time in the calorimeter. Nuclear physical monitors are not entirely satisfactory, but it may be possible to use as monitors chemical systems whose behaviour has been studied under carefully controlled conditions. Experiments on the irradiation of various systems are described, and it is shown that the oxidation of ferrous sulphate in 0·8 N H_2SO_4 provides a suitable monitor for short irradiations. Experiments in which this system is used to study transient pile phenomena provide information about one component of pile radiation—the γ-radiation resulting from decay of fission products. The results show the importance of attaining steady pile conditions and emphasize the fallibility of megawatt-hours as a measure of dose. Certain results suggest that the chemical effects of neutrons and of γ-rays are not always additive for a mixed source, but further confirmation by more direct experiments is being sought. The experiments described in the present paper have been designed and monitored in such a way that they can be related to the calorimetric measurements when these are complete. It will then be possible to derive *G* values for pile radiation for the various systems studied. A.

DISPERSIONS . COLLOIDS . ADSORPTION
541.18

541.18 : 536.7

11512. On the thermodynamics of micellar solutions. D. Stigter. *Recueil Trav. chim. Pays-Bas*, **73**, 593–610 (*Aug.*, 1954).

An equation is derived for the association equilibrium in micellar solutions. The activity corrections are discussed on a general basis and evaluated, in the appendices, for the case of spherical micelles surrounded by a diffuse electrical double layer. A.

541.18 : 541.132

11513. On the interpretation of the conductivity of soap solutions. D. Stigter. *Recueil Trav. chim. Pays-Bas*, **73**, 611–25 (*Aug.*, 1954).

It is shown that measurement of the conductivity of micellar solutions provides a fairly sensitive test for the size distribution of the micelles. In a number of systems the micelles are found to be practically uniform. In this case information on the equivalent conductance of the micellar soap can be obtained from the conductivity data in the range above the c.m.c. (central micelle conc.). The data in the transition range (around the c.m.c.) can be interpreted with the help of the law of mass action and lead to the molecular weight of the micelles. Anomalous conductivity curves with a maximum slope just above the c.m.c. are interpreted in terms of a wide size distribution of the micelles. A.

541.182.6 : 537.226.2

11514. The shapes of particles from dielectric constant studies of suspensions. A. P. Altshuller. *J. phys. Chem.*, **58**, 544–7 (*July*, 1954).

The variation of the theoretical linear coefficients, $\beta = (\varepsilon - \varepsilon_D)/\varepsilon_D V$, of spherical non-metallic particles in dilute suspensions is considered. The linear coefficients and shape factors, *f*, for dilute suspensions of randomly oriented spheroidal particles are discussed and the linear coefficients are tabulated as a function of particle shape and dielectric constant. The treatment by Polder and Van Santen of the dielectric constants of heterogeneous mixtures containing randomly distributed ellipsoidal particles or holes is expanded to include the case of dilute suspensions of ellipsoidal particles oriented with respect to the electric field. The variations of linear coefficients with particle shape and dielectric constant are tabulated for the case of complete orientation with respect to the electric field. A.

541.183

11515. The penetration of ions into charged films. J. T. Davies and E. K. Rideal. *J. Colloid Sci., Suppl. No.* 1, 1–8 (1954).

It has been shown that the Gouy equations for charged monolayers rest on assumptions which are not valid under certain conditions. These include high charge densities and the presence of large counter-ions. By means of studies of surface viscosities, potentials, pressures, reaction kinetics, desorption rates, dipole moment variations and ζ-potentials, a coherent qualitative explanation of deviations from the Gouy equations has been given. The conditions under which the Gouy equations hold satisfactorily have been stated. A.

541.183

11516. Adsorption of carbon dioxide on nickel single crystal surfaces using a radiotracer technique. J. A. Dillon, Jr and H. E. Farnsworth. *J. chem. Phys.*, **22**, 1601–5 (*Sept.*, 1954).

The adsorption of CO_2 (5·8% $C^{14}O_2$) on the (110) and (100) faces of a nickel single crystal has been studied, using an adsorption chamber containing a thin window Geiger counter. Maximum adsorption of CO_2 takes place on adsorbed residual gas layers of optimum thickness rather than on the clean nickel surface. The CO_2-nickel combination has a relatively low rate of adsorption ($1{\cdot}5 \times 10^{11}$ molecules per minute for each face). The observed equilibrium adsorption values on the (110) and (100) faces were about equal after 54 hours of outgassing at 985°c. After 32 additional hours of heating at 1085°c, the adsorption on the (110) face was twice that on the (100) face. Possible thermal etching of the (110) face makes the reason for this difference uncertain. At equilibrium on the (110) face, the surface coverage is about 2%. The equilibrium adsorption on the (100) face decreases linearly by 80% as the temperature is increased from 30°c to 110°c. A.

541.183 : 536.7

11517. Recent studies of the thermodynamics of physical adsorption. L. E. DRAIN. *Sci. Progr.*, **42**, 608–28 (*Oct.*, 1954).

CHEMICAL STRUCTURE 541.2/.6

541.5 : 539.132

The chemical significance of quadrupole spectra. *See Abstr.* 11287

541.5 : 539.132

Electron distribution in molecules. *See Abstr.* 11288–90

541.64

11518. Studies of rubberlike polymers by nuclear magnetism. V. R. HONNOLD, F. MCCAFFREY AND B. A. MROWCA. *J. appl. Phys.*, **25**, 1219–23 (*Oct.*, 1954).

The actual width of the proton resonance line in uncured natural rubber has been determined at room temperature to be 0·06 gauss. Curing of polymers increases the line width at a given temperature. The small increase in natural rubber is possibly compatible with a physical bonding rather than the usually assumed cross linking. For a butadiene-styrene copolymer the increase in line width due to cure is somewhat larger. Carbon black loading increases the line width to a lesser degree than cure. This is compatible with the concept of physical bonding between the blacks and the polymer chain molecules. Variations in line width caused by changes in chemical composition and copolymerization were also investigated. Polypropylene and polypropylene oxide of roughly the same average molecular weight are compared. The polypropylene oxide exhibits a greater degree of "rotation" about its C–O bonds than polypropylene does about its C–C bonds. Two butadiene-acrylonitrile copolymers also have been studied as a function of temperature. Finally, spin-lattice relaxation time *v.* temperature studies are reported for a butadiene-acrylonitrile copolymer and for raw butyl, over the temperature range from −50°C to 70°C. Estimates of the magnitude of the barriers hindering "rotation" are made. A.

541.65

11519. Rotativities of higher homologues of ethylene. R. DE MALLEMANN, F. SUHNER AND J. GRANGE. *C.R. Acad. Sci.* [*Paris*] **239**, 379–81 (*Aug.* 2, 1954) *In French.*

The magnetic rotativities, densities and refractivities of propene, butene-1, butadiene-1,3, pentene-1 and isoprene have been measured at various temperatures and pressures. The Verdet constant increases with increasing pressure whereas the molar refractivity exhibits little variation. G. I. W. LLEWELYN

541.66

11520. An additive function of critical constants for normal paraffins. S. S. MITRA. Letter in *J. sci. industr. Res.*, **13B**, 371–2 (*May*, 1954).

The expression $n/\log(T_c/P_c)$ is found to be a linear function of *n*, the number of carbon atoms in the molecule. W. GOOD

CHEMICAL ANALYSIS 543/545

545.8 : 539.16.08

11521. Analysis for trace impurities by neutron activation. W. A. BROOKSBANK, G. W. LEDDICOTTE AND H. A. MAHLMAN. *J. phys. Chem.*, **57**, 815–19 (*Nov.*, 1953).

The application of radioactivation analysis to selected examples of trace element determinations is reported. The technique of the method of neutron radioactivation analysis and the sensitivities of detection of these elements in a variety of materials are discussed. A.

545.8 : 539.16.08

11522. Ion-exchange separation of trace impurities. W. A. BROOKSBANK AND G. W. LEDDICOTTE. *J. phys. Chem.*, **57**, 819–23 (*Nov.*, 1953).

The use of ion-exchange separations in determining trace elements by neutron activation analysis (preceding abstract) is described. Activation analysis, coupled with ion-exchange techniques, becomes an extremely sensitive and specific method for the determination of small quantities of the rare earth and alkali elements in the presence of each other. This method has been applied to the analysis of rare earths in animal tissues and to the analysis of the alkali metals in pure chemical compounds and synthetics. A.

545.824 : 548.736 : 539.26

11523. Standard X-ray diffraction powder patterns. *Circ. Nat. Bur. Stand. No.* 539 (*June* 15, 1953). **Vol. I. Data for 54 inorganic substances.** H. E. SWANSON AND E. TATGE, 95 *pp.* **Vol. II. Data for 30 inorganic substances.** H. E. SWANSON AND R. K. FUYAT, 65 *pp.*

The patterns are presented as a revision of doubtful entries in the A.S.T.M. card file, together with a few not represented there.

545.827

11524. Trace element determination by the mass spectrometer. M. G. INGHRAM. *J. phys. Chem.*, **57**, 809–14 (*Nov.*, 1953).

The application of mass spectrometric technique to trace element determination in solids is reviewed. Three techniques which show promise are: (1) the Dempster vacuum spark method, (2) the ion bombardment method, and (3) the isotopic dilution method. Sensitivities of up to one part in ten to the tenth have been achieved. A.

545.827

11525. Determination of tritium by ion current measurement. K. E. WILZBACH, A. R. VAN DYKEN AND L. KAPLAN. *Analyt. Chem.*, **26**, 880–3 (*May*, 1954).

Since the measurement of ion current with the vibrating reed electrometer has proved highly satisfactory for carbon-14 assay, the applicability of this method to tritium determination has been investigated. Relative ion currents collected from several gases in a Borkowski chamber have been determined under various conditions. The results established that the current is proportional to the disintegration rate over a wide range of tritium concentrations and is not sensitive to changes in specified conditions of filling pressure and collecting voltage. As few as 10 disintegrations per second in 250 cm^3 of gas can be determined with an accuracy of 1%. The charge collected per disintegration has been determined in methane, propane and hydrogen by calibration with a known sample of tritium to permit conversion of ion currents to disintegration rates. A.

CRYSTALLOGRAPHY 548

548.1

11526. The geometrical basis of crystal chemistry. I. A. F. WELLS. *Acta cryst.*, **7**, 535–44 (*Sept.*, 1954).

An investigation is made of the periodic three-dimensional systems of points in which each point is connected to thee others. These nets form the bases of the structures of a large number of crystals in which there are directed bonds or hydrogen bonds. A.

548.1

11527. The geometrical basis of crystal chemistry. II. A. F. WELLS. *Acta cryst.*, **7**, 545–54 (*Sept.*, 1954).

A procedure for the systematic derivation of three-dimensional 4-connected nets is outlined and applied to nets with 2, 3 and 4 points in the repeat unit. The relevance to crystal chemistry of nets containing loops (digons) is noted. Some of the simplest open packings of tetrahedra are indicated, and a number of more complex nets (4-, 5-, 6-, 8- and 12-connected) with cubic symmetry are listed. A.

548.5

11528. Segregation of impurities during the growth of germanium and silicon crystals. R. N. HALL. *J. phys. Chem.*, **57**, 836–9 (*Nov.*, 1953).

The segregation factors of impurities picked up by a growing crystal of germanium or silicon have been found to depend upon the growth rate and crystal orientation as well as upon the degree of stirring in the melt. This dependence is generally much greater for donor impurities than it is for acceptors and makes possible the growth of crystals containing large numbers of *p–n* junctions suitable for use in rectifiers and transistors. The assumption that impurity atoms are preferentially adsorbed at the surface of the crystal leads to an expression for the growth-rate variation which is consistent with the experimental results. Calculated impurity distributions are presented for a number of periodic growth cycles of practical interest. A.

548.5

11529. Tellurium single crystals by the Czochralski procedure. J. WEIDEL. Note in *Z. Naturforsch.*, **9a**, 697 (*July–Aug.*, 1954) *In German.*

The crystals (8 cm long, 1 cm dia.), grown from almost spectroscopically pure Te (10^{-4}% C content) in a C crucible under a H_2 atmosphere at 0·1–0·4 mm/min, were bounded by $\{10\bar{1}0\}$ planes parallel to the [0001] growth direction. Conductivity measurements indicated that little segregation of impurities occurred, the distribution coefficient for Sb is approx. 0·5. J. FRANKS

548.5 : 537.312.62

11530. The structures of superconductors. I. Study of the system bismuth/nickel. Preparation and investigation of single crystals of Bi_3Ni. G. S. ZHDANOV, V. P. GLAGOLEVA, N. N. ZHURAVLEV AND YU. N. VENEVTSEV. *Zh. éksper. teor. Fiz.*, **25**, *No.* 1 (7), 115–22 (1953) *In Russian.*

Diagrams showing hardness and density of solid phases in the Bi–Ni system were constructed. BiNi, which has the NiAs structure, was both the hardest and densest phase to appear. Either BiNi or Bi_3Ni crystals could be produced from the same melt, depending on the degree of superheating. A technique for the production of the latter was elaborated and the unit cell was measured. [See Abstr. 11567 (1954) for full details. For Pt II, see Abstr. 11077 (1954).] A. L. MACKAY

548.5 : 548.736.3

11531. On In_2Te_3, its preparation and lattice constant. H. INUZUKA AND S. SUGAIKE. *Proc. Japan Acad.*, **30**, 383–6 (*May*, 1954).

In_2Te_3 crystals were grown in sealed silica crucibles, using Lawson's double furnace technique [Abstr. 2233 (1952)]. The lattice constant is 18·40 ± 0·04 Å, space group *F*43*m*. The density at 20°C is 5·78 ± 0·04 g/cm^3. J. FRANKS

548.51

11532. An experimental contribution to the question of the existence of crystal nuclei in over-heated melts and undersaturated solutions. C. W. CORRENS. *Nachr. Akad. Wiss. Göttingen math.-phys. Kl. IIa, No.* 9, 129–33 (1953) *In German.*

A discussion in more general terms and with some additional details of the experimental arrangements of the experiments reported in Abstr. 5117 (1954). S. WEINTROUB

548.55

11533. Formation of single crystal silicon fibers. E. R. JOHNSON AND J. A. AMICK. Letter in *J. appl. Phys.*, **25**, 1204 (*Sept.*, 1954).

Details of the experimental arrangements for the preparation of the fibres by saturating a carrier gas (A or H) with $SiCl_4$ at room temperature and reacting the mixture with Zn vapour at about 800–1000°C are given. The fibres were examined with a high-voltage electron microscope, and micrographs and the diffraction pattern given indicate that the fibres are single crystals and grow along the 111 axis. The *d*-values calculated from the diffraction pattern are tabulated and compared with the ASTM index and NBS values. The fibres were about 1 μ in diameter and up to 1 cm long, with rough edges and with indications from their internal structure that spiral dislocations may take part in the growth. S. WEINTROUB

548.58

11534. Physical chemistry of ionic crystals involving small concentrations of foreign substances. C. Wagner. *J. phys. Chem.*, **57**, 738–42 (*Nov.*, 1953).

The role of lattice defects for solubility problems in ionic crystals is shown. The following cases are discussed: (1) The distribution of $SrCl_2$ between solid and liquid KCl. (2) The decrease in the solubility of Ag_2S in ZnS due to the presence of Cu_2S. (3) The change in the metal/non-metal ratio in a solvent crystal due to the presence of solutes having a greater or a smaller cation/anion ratio than the solvent crystal. A.

MOLECULAR AND X-RAY CRYSTALLOGRAPHY 548.7

548.7

11535. The surface stability of alkali halide crystals. D. Patterson. *Trans Faraday Soc.*, **48**, 877–87 (*Oct.*, 1952).

The lattice constant of an alkali halide crystal is greater than that of the two-dimensional (100) lattice in equilibrium. The dilatation of the two-dimensional lattice in forming the (100) surface of an alkali halide crystal results in instability of the surface if sufficiently great. An ion-doublet surface structure has been predicted for certain alkali halides on these grounds. It is shown in the present paper that withdrawing an assumption of equal polarizabilities of metal and halogen ions and considering van der Waals forces leads to a denial of this prediction. The effect of different distances of metal and halogen surface ions from the substrate is also considered. A.

548.7

11536. On the theory of cooperative phenomena. S. Katsura. *Progr. theor. Phys.*, **11**, 476–92 (*April–May*, 1954).

The partition function of the Ising lattice which has a small number of lattice points on each side (edge) has been obtained. Such a partition function is convenient to consider several general properties of the lattice because of its closed form. The effect of the external magnetic field, Curie point of the three-dimensional lattice, and the theory of condensation by cluster integrals are discussed. A.

548.7

11537. Lattice vibrational spectrum of imperfect crystals. K. F. Stripp and J. G. Kirkwood. *J. chem. Phys.*, **22**, 1579–86 (*Sept.*, 1954).

The influence of lattice defects on the normal modes of vibration of crystals is investigated by means of perturbation theory. The calculations have been carried to the second order, and the effect of holes on the vibrational partition function has been determined. It is found that through their influence on the lattice vibrational free energy, a pair of holes in a crystal attract each other with an average force whose potential diminishes asymptotically as $1/R^6$. A.

548.7

11538. Note on the slow electrons in a polar crystal. E. Haga. *Progr. theor. Phys.*, **11**, 449–60 (*April–May*, 1954).

A new perturbation technique is developed to investigate the properties of a slow electron in a polar crystal at absolute zero. The low-lying energy levels in a conduction band are calculated up to the order of K^2 by the second-order perturbation calculation, where $\hbar K$ is the total momentum of the system, i.e. that of the polaron. For $K = 0$ the energy agrees nearly with that obtained by the variational method. In the neighbourhood of $K = 0$ the effective mass becomes $m(1 - a/6)^{-1}$, a being the coupling constant between an electron and the longitudinal optical modes of lattice vibrations. It is also shown that for $K = 0$ the eigenfunction and the eigenvalue of the total Hamiltonian obtained by the variational procedure coincide with those in the zero-th approximation of the present perturbation method. The second-order wave-function is constructed which enables one to calculate the electrostatic potential and the charge density due to the ionic polarization around the electron. A.

548.7

11539. Group theory and crystal lattices. D. G. Bell. *Rev. mod. Phys.*, **26**, 311–20 (*July*, 1954).

A method of obtaining the angular parts of one-electron wave-functions in all crystal lattices is discussed. The functions are shown to be bases for irreducible representations of rotation groups. Tables of these functions are given for use in cubic and close packed hexagonal lattices. Consideration is also given to angular wave-functions in polyatomic crystals. A.

548.7 : 539.11

Linear relations between Madelung constants. *See Abstr.* 11257

548.7

11540. Survey of imperfections in nearly perfect crystals. F. Seitz. *J. phys. Chem.*, **57**, 737–8 (*Nov.*, 1953).

The history of the understanding of the properties of crystalline solids is reviewed with particular emphasis on properties determined by imperfections. The interrelation of various types of crystalline imperfections is discussed from a unified viewpoint. A.

548.7

11541. Evidences of crystalline imperfections in nuclear magnetism. R. V. Pound. *J. phys. Chem.*, **57**, 743–8 (*Nov.*, 1953).

In the study of nuclear paramagnetic resonance several evidences of crystalline imperfections have been observed. First, the subject of spin-lattice equilibrium is discussed and the relaxation by impurities, with a spin-diffusion mechanism as suggested by Bloembergen, is described. Evidences of such effects from X-ray induced magnetic centres in LiF are described and an experiment demonstrating a strong anisotropy in the resultant relaxation time as a function of crystalline orientation in the field is discussed. Intensity measurements of the resonances of Br^{79}, Br^{81} and I^{127} in KBr and KI and the discovery, by Watkins, of the effect of lattice dislocations in such cubic crystals are next described. It is found that an average electric quadruple interaction must exist, even in crystals of ostensibly cubic symmetry, and from the observations estimates of the densities of dislocations in "perfect" and in "work-hardened" crystals are made. Finally, some evidences of crystalline strain from line width observations in pure quadrupole resonance are described. A.

548.7

11542. Geometry of the formation of the dislocation network by the condensation of vacancies. F. E. Fujita. *Sci. Rep. Res. Insts Tôhoku Univ. A*, 6, 125–9 (*April*, 1954).

When ring dislocations of the Seitz type are formed on the (110) atomic planes in the face-centred cubic lattice solidified from the melt, the hexagonal and three-dimensional network can be formed by the growth and reactions of the ring dislocations. A.

548.7 : 537.311.33

The effect of thermally produced lattice defects on the electrical properties of Te. *See Abstr.* 11062

548.7

11543. Electrical measurement of numbers of lattice defects in alkali halide crystals produced by X-rays. K. Sakaguchi and T. Suita. *Technol. Rep. Osaka Univ.*, **2,** *Paper* 43, 177–82 (*Oct.*, 1952).

The change in length of alkali halide crystals due to X-ray irradiation measured by an electric micrometer is reported. Coloration of the crystals and the increase in length occur simultaneously. Saturation of the increase in length was found about 4 hours after the irradiation started. These results seem to show that lattice defects consisting of pair vacancies diffuse from the crystal surface into internal sites. Assuming that this increase in length is mainly caused by pair vacancies, the number of pair vacancies produced by X-rays is 10^{17}–10^{19}/cm^3, and their activation energy of migration is 0·35 eV. These values seem to be in reasonable agreement with the theoretical and other experimental results. A.

548.7

11544. Alkali halides colored by colloidal metal. A. B. Scott, W. A. Smith and M. A. Thompson. *J. phys. Chem.*, **57,** 757–61 (*Nov.*, 1953).

Alkali halides coloured with an excess of alkali metal develop absorption bands due to colloidal metal upon moderate heating, provided the concentration of alkali metal is above the stable concentration of *F*-centres at the treatment temperature. The extinction is due almost entirely to absorption, rather than scattering, unless the particle size is greatly increased by extended treatment. The location of the band maxima in NaCl, KCl, KBr and KI can be satisfactorily calculated from the optical properties of the metal. The particle size range for the smaller particles is within the limits 10–50 Å. The heat of dissociation of colloid in the four lattices is calculated. A new band in KI which has many characteristics of a colloidal band, but which absorbs in a region far from that calculated for colloidal potassium is described. A.

548.7

11545. The interaction of color centres with their environment. J. J. Markham. *J. phys. Chem.*, **57,** 762–72 (*Nov.*, 1953).

Two types of interaction (macroscopic and microscopic) seem to exist. The macroscopic interactions appear in the rates at which bands are formed during irradiation and in the bleaching rates of colour centres in the dark and in the light. The microscopic interactions appear in the shape of the band and in the bleaching properties at very low temperatures. Further data have been obtained to indicate that the *F*-centre bleaches at 5°K and that its bleaching characteristic depends on the way it was formed. It is believed that the bleaching at 5°K is a result of tunnelling rather than of the migration of free electrons. This synthesis attempts to show that a great deal more data are needed to establish all the properties of these effects and to develop an adequate theory. A.

548.7

11546. Effects of impurities on the coloration of solids by ionizing radiations. J. H. Schulman. *J. phys. Chem.*, **57,** 749–52 (*Nov.*, 1953).

Impurities influence the coloration of solids under ionizing radiations directly by providing new traps for electrons and holes, and indirectly by altering the concentration of trapping defects in the solid due to mismatch in size, polarization properties and electrostatic charge. Illustrations are given of these effects. Attention is directed to the possibility that certain coloration phenomena generally ascribed to the host crystal may be due to traces of impurities. The preparation of very high-purity crystals is desirable to permit investigation of this possibility. A.

548.7

11547. Traps and trapping processes. R. H. Bube. *J. phys. Chem.*, **57,** 785–90 (*Nov.*, 1953).

Both emission centres and trapping centres are associated with localized imperfections in crystals. There are many cases in which these localized imperfections are caused by the presence of added impurities, but there are other examples of emission centres and trapping centres being associated with imperfections of the crystal defect type. Crystal defects thus may be considered as a kind of "intrinsic impurity" which plays an important role in the formation of host-crystal emission centres and host-crystal trapping centres. The results reported in this paper give some recently suggested answers to the following questions. (1) What is the nature of the trapping centres? (2) Is trapping dependent on the motion of the excited electron through the conduction band? (3) Is retrapping an important phenomenon? (4) What is the transition involved in optical trap emptying? Studies of trapping have yielded the following answers to these questions. (1) Trapping centres in sulphide (and silicate) phosphors are associated with crystal defects located at substitutional sites. This conclusion is based on the evidence that (*a*) traps occur in phosphor without added impurity, (*b*) trap depths are independent of added impurity, (*c*) trap depths are independent of crystal form, (*d*) the number of traps increases exponentially with the reciprocal preparation temperature, (*e*) intensification effects are found in which an added impurity increases the number of host-crystal emission centres and host-crystal trapping centres, (*f*) the excitation of photoconductivity varies in the same way with excitation energy at the production of trapped electrons, indicating a separate identity for emission centres and trapping centres. (2) At least in sulphide phosphors, trapping is always accompanied by photoconductivity, indicating that electrons move in the conduction band to and from traps. (3) Retrapping occurs whenever the number of empty traps becomes appreciable. (4) If optical trap emptying produces stimulation, trapped electrons are raised into the conduction band, whereupon they may be retrapped or return to emission centres. A.

548.7

11548. The effect of hydrostatic pressure on the *F*-bands in alkali halides. R. Kiyama and S. Minomura. *Proc. Japan Acad.*, **30**, 199–203 (*March*, 1954).

The *F*-bands of LiCl, KBr and KCl, produced by exposure to $RaBr_2$, are shifted to shorter wavelengths and broadened when crystals are subjected to pressures up to 75 000 atm. The spontaneous bleaching also decreases with increasing pressure. J. E. CAFFYN

548.7

11549. Low-temperature bleaching and restoration of color centers. A. Halperin and G. F. J. Garlick. Letter in *Phys. Rev.*, **95**, 1098–9 (*Aug.* 15, 1954).

It is shown that the reported increase in *F*- and *V*-band absorption of X-ray irradiated KCl on warming [see Hesketh and Schneider, Abstr. 7863 (1954)] is not associated with these centres but is due to effects of vapour films condensing on the crystal surfaces during the warming process. G. F. J. GARLICK

548.7

11550. Silver-activated alkali halides. H. W. Etzel and J. H. Schulman. *J. chem. Phys.*, **22**, 1549–54 (*Sept.*, 1954).

The emission, excitation and absorption spectra of silver-activated alkali halides have been investigated. Three absorption bands due to ionic silver have been observed in NaCl, NaBr, KCl and KBr, and the growth of these bands with silver concentration has been studied. In each of these crystals the two shorter-wavelength bands are ascribed to isolated silver ions, while the band of longest wavelength is ascribed to pairs of silver ions. Upon X-ray irradiation as many as five new absorption bands arise in certain alkali halides in addition to the *F* band. Excitation into three of these bands (designated as the *B*, *C* and *D* bands) produces luminescence, the emission spectrum being different for each band. The *B* band is attributed to a centre consisting of an electron trapped at a silver ion adjacent to a halogen-ion vacancy; the *C* band to an electron trapped at a complex of two silver ions adjacent to a halogen-ion vacancy; and the *D* band to a hole trapped at an alkali-ion vacancy adjacent to a silver ion. A.

548.7

11551. Plastic flow and the low-frequency dispersion in the alkali halide crystal. M. Ishiguro, F. Oda and T. Fujino. Letter in *Phys. Rev.*, **95**, 1347–8 (*Sept.* 1, 1954).

Measurement of loss angle with temperature for NaCl crystals in 1000 c/s field shows a peak at 120°c for plastically deformed crystals which disappears on reannealing. Plastically deformed or quenched crystals coloured by X-rays show no 120°c peak, but this appears on bleaching. The results suggest that the anomalous dispersion peak is due to irregular dislocation segments resulting from localization of free vacancies. X-ray coloration forms free isolated colour centres and so reduces the vacancy clusters. G. F. J. GARLICK

548.7 : 537.529 : 537.226.8

Space-charge effects in dielectric breakdown of solids. *See Abstr.* 11036

548.7 : 538.63 : 537.311.33

Electrical properties of Te crystals at very low temperatures. *See Abstr.* 11061

548.73/.74 : 539.26/.27

X-ray and electron investigation of materials. *See Abstr.* 11475–9

548.73

11552. Summarized proceedings of a conference on X-ray analysis—Cambridge, April, 1954. W. Cochran. *Brit. J. appl. Phys.*, **5**, 345–48 (*Oct.*, 1954).

This conference of the X-ray Analysis Group of The Institute of Physics was concerned with new developments in crystal-structure analysis and their applications. A.

548.733

11553. Multiple film methods in X-ray powder photography. R. J. Davis and W. E. Armstrong; J. Iball. Letters in *J. sci. Instrum.*, **31**, 305–6 (*Aug.*, 1954).

The first two authors describe the application of the modified multiple film technique [Abstr. 4005 (1954)] to powder photographs. Using films of different sensitivities they find it possible to record weak diffuse lines on one film and strong lines on another when studying materials such as carbon deposits. In addition they find the method useful when dealing with materials which produce fluorescent radiation. The last author comments on the above and points out the necessity of determining the intensity ratio for every batch of films. J. IBALL

548.734

11554. A new photographic method for studying the texture of large single crystals. A. R. Lang. *Acta cryst.*, **7**, 583–7 (*Sept.*, 1954).

The orientation, in one plane, of macromosaic regions covering a crystal face several centimetres long may be determined from one photograph of the reflection pattern of characteristic radiation when the film-to-crystal distance is made large compared with that between crystal and X-ray source, and a grid placed in front of the film is rotated in synchronism with the crystal rotation. A line X-ray source parallel with the crystal rotation axis is used. The reflections are rapidly interpreted with the aid of a master pattern given by a good crystal which need not be of same material as the specimen. A.

548.734

11555. Spurious areas in pole figures. A. H. Geisler. *J. appl. Phys.*, **25**, 1245–9 (*Oct.*, 1954).

Spurious maxima are frequently observed in pole figures determined by X-ray diffraction techniques employing the Geiger-counter spectrogoniometer. Their origin must be fully understood in order to avoid misleading interpretations of the pole-figure data. By making film patterns and by the balanced filter technique—in each case with the specimen oriented for the appearance of one of the spurious peaks—these spurious maxima can be identified as diffraction of a component from the white radiation by a strongly diffracting (*hkl*) plane, and at a 2θ angle corresponding to K_α diffraction from the (*hkl*) plane under investigation. Spurious (110) and (112) peaks of this type may be observed in the (200) pole figure of iron and its alloys; spurious (111) and (220) peaks may appear in the (200) pole figure of face-centred-cubic metals such as nickel. These cannot be completely suppressed by filtering the Mo radiation used or by modifying the operating conditions such as tube voltage, spectrometer resolution, or counter type. Spurious ($10\bar{1}1$) peaks may appear in the (0002) pole figure of titanium and zirconium as the result of Cu K_α diffraction, and they can be avoided by increasing the resolution of the slit system. A.

548.734.84

11556. The determination of signs of structure factors from the intensities. W. Cochran. *Acta cryst.*, **7**, 581–3 (*Sept.*, 1954).

It is shown that in principle the magnitudes and signs of certain structure factors can be calculated from a sufficient range of X-ray intensities. The range provided by experiment will seldom be enough to make the results of practical value. A.

548.735

11557. The use of radial distribution curves and spherical Fourier transforms in the determination of the structure of high polymers by X-ray diffraction methods. D. P. Riley and U. W. Arndt. *J. Colloid Sci., Suppl. No.* 1, 57–65 (1954).

The intensity of monochromatic X-rays scattered by an isotropic specimen is measured over a large angular range. By "isotropic" it is meant that the molecular units it is desired to examine are in random orientation (e.g. a powdered specimen compressed into a block, a sheet showing optically no preferred orientation, or a compact of finely chopped-up fibres). From the experimental intensity curve, it is possible by a process of Fourier inversion to derive a spherical transform, or radial distribution curve, characteristic of the average atomic environment in the specimen. A.

548.735

11558. Analysis of the small-angle scattering by means of the "folding" operations. R. Hosemann. *Z. Elektrochem.*, **58,** *No.* 4, 271–80 (1954) *In German.*

Analyses the general properties of the *Q*-function [Abstr. 7310 (1953)] for any substance. For an infinitely large single crystal it degenerates to the Patterson function. The *Q*-function is a sum of a particle-scatter term and an interaction term; its special field are the polydisperse agglomerations, and clusters, of particles. Demonstrates the inconsistency of the interference theory of a densely-packed colloidal system, suggested by Porod [*Kolloid-Zeitschrift*, **124,** 83 (1951); **125,** 51 and 108 (1952)]. F. LACHMAN

548.735

11559. Determination of structures by the direct method by means of Eller's machine. I. L. Brú, M. Cubero and M. Pérez Rodríguez. *An. Real. Soc. Españ Fís. Quím.*, **50(A)**, 105–6 (*May–June*, 1954) *In Spanish.* See Abstr. 5002 (1951).

548.735

11560. Optical method for the "refinement" of crystal structures. L. Brú, M. P. Rodríguez and M. G. Gea. *An. Real. Soc. Españ. Fís. Quím.*, **50(A)**, 133–4 (*July–Aug.*, 1954) *In Spanish.*

The influence of the temperature factor and the non-isotropic vibrations is studied using Eller's machine. A.

548.735.44

11561. The use of Fourier analysis in the interpretation of X-ray line broadening from cold-worked iron and molybdenum. G. K. Williamson and R. E. Smallman. *Acta cryst.*, 7, 574–81 (*Sept.*, 1954).

Measurements of the line shapes in the Debye–Scherrer spectra of iron and molybdenum, cold worked by filing, have been made using a Geiger–counter spectrometer. Fourier coefficients of the broadening functions have been calculated, using the coefficients for the annealed specimen as a measure of the instrumental broadening. The values of the r.m.s. strain deduced from the 110 and 220 reflections do not coincide, but differ by 30–50%. An investigation into the coefficients of theoretical line shapes has been made, and a similar effect has been found for the case of broadening due to a "Cauchy" strain distribution. Equations which have previously been thought to make no *a priori* assumptions as to line shape are shown to hold only for very restricted cases not likely to occur in practice. The unavoidable numerical errors in calculating the coefficients from any profile resembling a "Cauchy," even with better-than-average experimental accuracy, appear to make rigorous analysis impossible. A semi-empirical approach is suggested, which, at least for the iron and molybdenum results, allows an accuracy bracket to be placed on the interpretation. The reliability of some important previous results is discussed. A.

548.736 : 539.26 : 545.824

Standard X-ray diffraction powder patterns. *See Abstr.* 11523

548.736.1

11562. The crystal structure of electrodeposited silver. D. N. Layton. *J. Electrodep. Tech. Soc.*, **28,** 239–44 (1952).

548.736.1

11563. X-ray measurements on lithium at low temperatures. E. A. Owen and G. I. Williams. *Proc. Phys. Soc.* [*London*] *A*, **67,** 895–900 (*Oct.*, 1954).

Results are given of X-ray measurements on the variation of the lattice parameter of lithium with temperature. The mean thermal coefficient of expansion of lithium varies from $3{\cdot}5\times10^{-5}$ at -194°c to $4{\cdot}7\times10^{-5}$ at 20°c. The expansion of the material over this range of temperature is closely represented by the equation $a_t = a_0(1 + \alpha t + \beta t^2 + \gamma t^3)$ where $a_0 = 3{\cdot}4992$ kX; $\alpha = 4{\cdot}6640\times10^{-5}$; $\beta = 3{\cdot}8791\times10^{-8}$; $\gamma = -\,11{\cdot}445\times10^{-11}$. After deformation at liquid air temperature lithium is found to contain a face-centred cubic structure as well as a body-centred cubic structure, which confirms the findings of Barrett [Abstr. 3351 (1947)]. The lattice parameters of these structures at −194°C were found to be 3·4760 kX (body-centred cubic) and 4·370 kX (face-centred cubic). After annealing the material at room temperature and afterwards obtaining its X-ray pattern at liquid air temperature the body-centred cubic structure remained alone. A.

548.736.3 : 537.312.62

11564. The structures of superconductors. III. X-ray crystallographic study of the structures and solubilities of the components in BiRh. V. P. GLAGOLEVA AND G. S. ZHDANOV. *Zh. éksper. teor. Fiz.*, **25**, *No.* 2 (8) 248–54 (1953) *In Russian.*

For Pt II, see Abstr. 11077 (1954). Crystals of BiRh were found to be hexagonal with cell dimensions $a = 4{\cdot}094 \pm 0{\cdot}001$ and $c = 5{\cdot}663 \pm 0{\cdot}002$ Å. $Z = 2$, $\rho_{\text{obs.}} = 12{\cdot}5 \pm 0{\cdot}4$ g/cm³ and the space group is C6/mmc. The structure is of the NiAs type. A compression of about 15% of the BiRh cell along the *c*-axis in comparison with the ideal NiAs type leads to an increase in the co-ordination numbers of Rh atoms to 8 and of Bi atoms to 12. $BiRh_x$ is a phase of variable composition within the limits $0{\cdot}81 \leqslant x \leqslant 0{\cdot}91$. This variability explains the variation in the temperature of transition to the superconducting state. A. L. MACKAY

548.736.3 : 537.312.62

11565. The structures of superconductors. V. X-ray crystallographic study of the structure of BiPd. D. M. KHEĬKER, G. S. ZHDANOV AND N. N. ZHURAVLEV. *Zh. éksper. teor. Fiz.*, **25**, *No.* 5 (11) 621–7 (1953) *In Russian.*

For Pt IV, see Abstr. 10664 (1954). Crystals of BiPd are orthorhombic with unit cell dimensions $a = 7{\cdot}203 \pm 0{\cdot}001$, $b = 8{\cdot}707 \pm 0{\cdot}002$ and $c = 10{\cdot}662 \pm 0{\cdot}001$ Å. The space group is Ama2, $Z = 16$ and $\rho_{\text{obs.}} = 12{\cdot}5$ g/cm³. Geometrical analysis and the Patterson summations $P(0yz)$ and $P(x0\frac{1}{2})$ gave phases from which the Fourier projections $F(xy0)$ and $F(0yz)$ were calculated. The structure obtained confirmed the choice of space group. The uncentred structure of BiPd is like that of the centred TlI structure with distortion of the polyhedra. This appears to be the first non-centrosymmetric structure which has been observed to possess superconducting properties. A. L. MACKAY

548.736.4 : 537.312.62

11566. The structures of superconductors. VI. X-ray crystallographic study of the structure of the low-temperature modification of Bi_2Pd. L. S. ZEVIN, G. S. ZHDANOV AND N. N. ZHURAVLEV. *Zh. éksper. teor. Fiz.*, **25**, *No.* 6 (12) 751–4 (1953) *In Russian.*

The dimensions of the monoclinic unit cell of α-Bi_2Pd were found to be $a = 12{\cdot}74 \pm 0{\cdot}01$, $b = 4{\cdot}25 \pm 0{\cdot}02$ and $c = 5{\cdot}665 \pm 0{\cdot}005$ Å with $\beta = 102^0\ 35' \pm 10'$. The space group is C2/m, $\rho_{\text{obs.}} = 11{\cdot}5$ g/cm³ and $Z = 4$. The Bi and Pd atoms lie in the planes of symmetry with the parameters (x, y, z): Bi I (0·156, 0, 0·321); Bi II (0·076, ½, 0·796); and Pd (0·226, 0, 0·820). The structure is closely related to those of β-Bi_2Pd and BiPd. A. L. MACKAY

548.736.4 : 537.312.62

11567. The structures of superconductors. VII. X-ray crystallographic determination of the structure of Bi_3Ni. V. P. GLAGOLEVA AND G. S. ZHDANOV. *Zh. éksper. teor. Fiz.*, **26**, *No.* 3, 337–44 (1954) *In Russian.*

The unit cell of the superconductor Bi_3Ni is orthorhombic with dimensions $a = 8{\cdot}875 \pm 0{\cdot}006$, $b = 4{\cdot}112 \pm 0{\cdot}004$ and $c = 11{\cdot}477 \pm 0{\cdot}008$ Å. $Z = 4$, the space group is Pnma and the observed density $10{\cdot}1 \pm 0{\cdot}8$ g/cm³. Fourier projections on 010, using phases derived from geometrical considerations gave the *x* and *z* atomic co-ordinates as follows: Bi I (0·411, 0·179); Bi II (0·385, 0·591); Bi III (0·294, 0·891); Ni (0·08, 0·52). All atoms lie on mirror planes. A. L. MACKAY

548.736.4

11568. Structure of a new variety of sodium ferrite ($FeNaO_2$). F. BERTAUT AND P. BLUM. *C.R. Acad. Sci.* [*Paris*] **239**, 429–31 (*Aug.* 2, 1954) *In French.*

548.736.4

11569. Study of the deformations in some copper spinels. F. BERTAUT AND C. DELORME. *C.R. Acad. Sci.* [*Paris*] **239**, 504–5 (*Aug.* 9, 1954) *In French.*

Fe_2CuO_4 and $GeCo_{2-x}Cu_xO_4$ are tetragonal, the ratio $c/a (>1)$ increasing with the Cu^{++} ion concentration on the octahedral sites. Al_2CuO_4 is cubic and partially inverse. Cr_2CuO_4 is tetragonal ($c/a = 0{\cdot}92$), and appears normal at all temperatures. A.

548.736.4

11570. Cation distribution and *g*-factors of certain spinels containing Ni^{++}, Mn^{++}, Co^{++}, Al^{+++}, Ga^{+++}, and Fe^{+++}. S. GREENWALD, S. J. PICKART AND F. H. GRANNIS. *J. chem. Phys.*, **22**, 1597–600 (*Sept.*, 1954).

X-ray measurements on $NiOAl_2O_3$, $MnOAl_2O_3$, and $CoOAl_2O_3$ show that the Ni spinel is almost completely inverted, the Mn partially so, and the Co compound almost completely normal. This information combined with the magnetic susceptibility *v.* temperature data yields a *g*-value of approximately 4·0 for both tetrahedrally co-ordinated Ni^{++} and for octahedrally co-ordinated Co^{++}. X-ray measurements indicate that the Ni^{++} ion also prefers the octahedral site in $NiOGa_2O_3$, $NiOFe_{1\cdot00}Al_{1\cdot00}O_3$ and $NiOFe_{0\cdot25}Al_{1\cdot75}O_3$. A.

548.74

11571. Neutron diffraction studies of a nickel zinc ferrite. V. C. WILSON AND J. S. KASPER. *Phys. Rev.*, **95**, 1408–11 (*Sept.* 15, 1954).

Studies have been made of a ferrite powder of composition $Zn_{0\cdot5}Ni_{0\cdot5}Fe_2O_4$. The crystal structure is of the spinel type with 4 Zn^{++} and 4 Fe^{+++} ions in the tetrahedral positions and 4 Ni^{++} and 12 Fe^{+++} ions in the octahedral positions. The magnetic structure at 25°C appears to have an antiparallel arrangement of the Fe^{+++} spins on the two sites and a random orientation of the Ni^{++} spins. A.

GEOPHYSICS 55

550.36

11572. Heat flow in the Transvaal and Orange Free State. A. E. Carte. *Proc. Phys. Soc.* [*London*] *B*, 67, 664–72 (*Sept.*, 1954).

The thermal conductivity of 46 rock samples and the temperature at a number of points along the lengths of three boreholes were measured. The heat flow from the earth is derived from these and other measurements of temperature and conductivity. Values of the heat flow lie in the region $(1 \cdot 1 \pm 0 \cdot 3) \times 10^{-6}$ cal cm^{-2} sec^{-1}. A.

550.361

11573. Borehole temperature measuring equipment and the geothermal flux in Tasmania. G. Newstead and A. Beck. *Austral. J. Phys.*, 6, 480–9 (*Dec.*, 1953).

An instrument, using a thermistor and an a.c. bridge circuit, is described by which temperature measurements in boreholes can be made to 0·01°c. Results of temperature measurements in Tasmania are given and a value of 2 cal cm^{-2} sec^{-1} is obtained for the heat flux (uncorrected for recent glaciation). A.

550.38

11574. On a self-exciting process in magnetohydrodynamics. H. Takeuchi and Y. Shimazu. *J. geophys. Res.*, **58**, 497–518 (*Dec.*, 1953).

In connection with the convection-current model proposed by Bullard [Abstr. 4289 (1949)], the problem here considered is whether the magneto-hydrodynamical equations have a solution representing the self-exciting process which is appropriate to the model. The general expressions for the magnetohydrodynamical couplings are obtained and, using these results, the problem is reduced to solving under the boundary conditions. This is the eigenvalue problem for $4\pi\kappa\alpha V$ (κ is the electric conductivity, α the radius of the earth's core and V the fluid velocity). This eigenvalue problem is solved in an approximate way, and this solution is shown to be satisfactory for studying the problem. The results obtained show that such a self-exciting dynamo is possible by which the earth's main magnetic field is produced and maintained. A.

550.38 : 551.510.535

11575. On the dynamo theory of geomagnetic field variations. S. K. Chakrabarty and R. Pratap. *J. geophys. Res.*, **59**, 1–14 (*March*, 1954).

The dynamo theory developed by Stewart, Schuster and Chapman in order to explain the geomagnetic field variations no doubt gives qualitative explanations for the observed variations but differs appreciably in details. In the present paper, the analysis of Chapman has been modified and the dynamo equations have been solved without introducing approximations which are difficult to justify. The solution of the dynamo equation has been given in the most general form, which can be used for any given "ionospheric conductivity" and "atmospheric oscillations." The results obtained have been compared with those of Chapman, which show the effect introduced in the final result by the approximations used by Chapman. The results have been utilized also to calculate the diurnal variations in horizontal and vertical intensities, and these have been compared with the observed data. The results show that with a reasonable assumption for the conductivity and the atmospheric oscillations, the dynamo theory can very well explain the observed facts. A.

550.382

11576. Rock magnetism—some recent developments. J. McG. Bruckshaw. *Sci. Progr.*, **42**, 406–18 (*July*, 1954).

550.42

11577. On the spontaneous fission of terrestrial uranium. C. Festa and M. Santangelo. *Ann. Geofis.*, **5**, 551–60 (*Oct.*, 1954) *In Italian.*

A rough determination of the Kr and Xe generated by the spontaneous fission of the terrestrial uranium during the last 3·3 billion years (earth's age) is attempted, based on the most recent data for the spontaneous fission mean life of U^{238}. From a comparison between the abundances of each isotope in atmospheric Kr and Xe and the abundances of the same isotope in fission Kr and Xe, one can estimate that the contribution of the spontaneous fission of U^{238} to the production of the atmospheric Kr and Xe is negligible. The fission Kr and Xe and the Kr and Xe content in the earth's crust (calculated following Brown's method) are also compared. The spontaneous fission of U does not seem negligible in this case. The great interest of the determination of the Kr and Xe content in rocks and natural gases and its isotopic composition is discussed. A.

550.838

11578. Calculation of the components of the magnetic field of masses of any shape. C. Contini. *Geofis. pura appl.*, **26**, 41–66 (1953) *In Italian.*

A description is given of the diagrams for computing the components of the magnetic field generated by the magnetization of elementary masses of rotation round a vertical axis. It is further shown how such diagrams, in variable scale, make it possible to make rapid and fairly correct computations of the elements of the field of magnetized masses of any shape and size. An explanation is given of how the same diagrams can also be used for computing the Eötvössian elements. At the end some details are given on the computation of topographic influences. A.

550.9 : 539.16 : 537.591

11579. Contribution to the study of the radioactivity induced by the cosmic radiation. M. Demeur, A. Gribaumont and P. Janssens. *Mem. Soc. Roy. Sci. Liège*, **14**, *Special No.*, 538–43 (1954) *In French.*

The neutrons emitted in nuclear evaporations will cause a certain amount of radioactivity by capture in the superficial layer of the earth's crust. This note develops an expression for the neutron spectrum at any point in the layer, and an example, applied to pure NaCl, is worked out. Corrections must be applied for (*a*) the neutron component of the cosmic radiation, (*b*) neutrons from nuclear evaporations in the atmosphere.

ATMOSPHERE . METEOROLOGY 551.5

551.501.8 : 551.576

11580. The estimation of cloud parameters by radar. D. ATLAS. *J. Meteorol.*, **11,** 309–17 (*Aug.*, 1954).

Although the radar-reflectivity factor $Z = \Sigma Nd^6$ is a function of the liquid-water content W, median volume diameter d_0 (or other characteristic diameter), and breadth of the drop-size distribution, correlations of Z *v.* W, and Z *v.* d_0, provide reasonable estimates of W and d_0 from Z alone. If two of the latter three are known, considerably more reliable estimates of the third parameter are possible. Estimates may also be improved somewhat by an observation of cloud type. A theoretically feasible, though instrumentally complex method for measuring cloud water-content is also described. The possibility of using reflectivity measurements for warnings of icing severity is discussed. The reflectivity statistics indicate that natural clouds have a preference for drop-size spectra between the $n = 2$ (B) and 3 (C) distributions of the "multi-cylinder" family. A.

551.501.8 : 551.594.221

11581. Radar echoes associated with lightning. V. G. MILES. *J. atmos. terrest. Phys.*, **3,** 258–62 (*June*, 1953).

Radar echoes believed to originate from lightning discharges have been observed both when the radar beam is directed into a thunderstorm overhead, and when the beam is set on to a distant storm. In the case of a thunderstorm overhead, the echoes have been photographed and are analysed in terms of the individual strokes comprising a lightning discharge, with special reference to the junction-streamer process. It is suggested that the echoes have their origin in ionide portions of the electric charge in the cloud. In the case of distant storms the echoes are described from visual observation. A.

551.508.19

11582. High altitude rocket research. H. E. NEWELL, JR. *New York: Academic Press* (1953) 298 + xiv *pp.* + 93 *figs.*

Review in *Rev. Sci. Instrum.*, **25,** 826–7 (*Aug.*, 1954).

551.508.19

11583. Rocket research in the upper atmosphere. R. L. F. BOYD. *Sci. Progr.*, **42,** 435–48 (*July*, 1954).

Review article describing the use of rockets and the observations that can be made.

551.508.2

11584. An improved net-radiation instrument. V. E. SUOMI, M. FRANSSILA AND N. F. ISLITZER. *J. Meteorol.*, **11,** 276–82 (*Aug.*, 1954).

An improved net-radiation instrument for measuring the net flux of radiant energy through a surface parallel to the earth's surface, which employs the principle of exposing a ventilated radiation-absorbing element to the radiation sources, is described. The importance of providing similar ventilation on both sides of the absorbing plate is pointed out, and the control features to insure this uniformity are described. A method of reducing the error due to the variation of the absorptivity of the blackened surface with wavelength is discussed. The performance of the instrument and the possible errors are described. It was found that the instrument is capable of giving net-radiation measurements accurate to within 2%. A.

551.508.2 : 551.524.7

11585. A note on the use of the Fabry–Perot etalon for upper atmosphere temperature measurements. E. B. ARMSTRONG. *J. atmos. terrest. Phys.*, **3,** 274–81 (*June*, 1953).

The possible value of the Fabry–Perot etalon in the measurement of upper atmosphere temperatures is put forward again, and some old observations by Babcock and Vegard are discussed. It is shown that background sky-light will introduce a serious error in temperature estimations based on the contrast in etalon photographs, and the work of Roach and Pettit with photoelectric photometers is used in an attempt to assess the magnitude of this error, with a view to allowing for it in future observations. A.

551.508.85 : 621.396.11.08

11586. An ionosphere recorder for low frequencies. J. C. BLAIR, J. N. BROWN AND J. M. WATTS. *J. geophys. Res.*, **58,** 99–107 (*March*, 1953).

Application to the l.f. case of techniques previously used in h.f. ionosphere recorders is described. The beat frequency method of generating wide frequency sweeps is used, covering frequencies from 50 kc/s to 1000 kc/s in a short time without band switching. Advantage is gained by the use of transformers containing ferromagnetic cores in the wide-band transmitter amplifiers, but the aerial system, for practical reasons, is very inefficient. Sample records are shown. A.

551.510.41

11587. The mean vertical ozone distribution resulting from the photochemical equilibrium, turbulence and currents of air. H.-K. PAETZOLD. *J. atmos. terrest. Phys.*, **3,** 125–31 (*April*, 1954).

The shape of the observed mean ozone distribution at various latitudes is explained by a combination of photochemical formation and destruction of the ozone, with turbulence and currents of air. Above 25 km the mean ozone distribution is principally determined by the photochemical equilibrium; below this height, turbulent exchange and air currents are of great importance. A.

·551.510.41 : 551.593.9

11588. Nitrogen in the upper atmosphere. S. DEB. *J. atmos. terrest. Phys.*, **2,** *No.* 6, 309–23 (1952).

An attempt has been made to find out from theorectical considerations the probable distribution of atomic nitrogen in the upper atmosphere. Two mechanisms of production of atomic nitrogen are considered: (i) predissociation of N_2 molecules by absorption in the Lyman–Birge–Hopfield band within the range 1150–1250 Å as suggested by Herzberg and Herzberg, and, (ii) dissociative recombination of N_2^+ ions and electrons as suggested by Mitra. It is shown that the N atoms thus produced will disappear largely through two-body radiative recombination process. The method of calculation employed for determining the distribution is a modification of the one adopted by Penndorf in estimating the dissociation of molecular oxygen in the upper atmosphere. The results show that while Herzberg and Herzberg's mechanism is operative within the range of heights 70–170 km, that of Mitra is effective in the much higher range—200–400 km. The dissociation in the former region is found to be less than 1% and the distribution of N atoms is found to have a sharp maximum round the height of 90 km. The dissociation in the latter region, on the other hand, is found to increase from 5% at 170 km to about 25% at 400 km, the distribution not showing any maximum (the rise is at first sharp; this is followed by a very slow but continuous increase with height). Calculations also show that the total number of N atoms in a vertical column of one cm^2 cross-section is about 10^{16}. Estimate has also been made of the abundance of N_2^+ ions in the upper atmosphere. It is shown that although these are largely removed through the dissociative recombination process, a sufficient number is still left to account for the observed twilight flash of negative bands of N_2^+ ions. The probable time required for the attainment of equilibrium of the various processes involved in the calculation is also considered. It is found that the concentration of N_2^+ ions reaches an equilibrium value very quickly, but it requires years for the concentration of N atoms to reach the same. A.

551.510.5

11589. The aeronomic problem of oxygen dissociation. M. Nicolet. *J. atmos. terrest. Phys.*, **5**, 132–40 (*July*, 1954).

The vertical distribution of molecular oxygen above 100 km, obtained from recent rocket data, cannot be explained by photochemical equilibrium. An aeronomic study of departures from photo-equilibrium conditions in the lower thermosphere shows that atmospheric mixing or diffusion must be operative. It is concluded that the process of diffusion contributes increasingly to molecular oxygen concentrations at greater heights. By considering a diffusive equilibrium, it is found that new information can be obtained for various aeronomic processes. A.

551.510.53

11590. A series of stratospheric temperature profiles obtained with the searchlight technique. L. Elterman. *J. geophys. Res.*, **58**, 519–30 (*Dec.*, 1953).

Measurements of atmospheric densities have been made with the searchlight technique, using improved instrumentation. The density distributions are sufficiently accurate so that corresponding temperature profiles are readily obtained. The density-temperature equation requires the evaluation of an integration constant, which is accomplished by using radiosonde information and, in addition, considering physically acceptable temperature lapse rates. Five temperature profiles are obtained which represent stratospheric conditions over New Mexico during October, 1952. The average height of the temperature maximum is 53 km and the mean value of the temperature maximum is 313°K. The average temperatures are calculated to 67·6 km. A.

551.510.53

11591. The dissociation of oxygen in the high atmosphere. M. Nicolet and P. Mange. *J. geophys. Res.*, **59**, 15–45 (*March*, 1954).

The question of the oxygen distribution in the high atmosphere is examined by studying the departure from photochemical equilibrium. An investigation of the transition region is made, utilizing recent rocket data on atmospheric transmission in the Schumann–Runge continuum of molecular oxygen. It is concluded that the molecular oxygen distribution above the dissociation region follows the distribution of the main atmosphere and depends on mixing effects. A limit for the time of mixing can be found when times of dissociation, recombination and diffusion are considered. It is shown that the level of the mesopause is related to the dissociation of the oxygen molecule. Some suggestions are made concerning dynamical effects affecting the airglow, formation of ionospheric regions and dissociation of nitrogen. A.

551.510.534

11592. Ozone layer and air-movements in the stratosphere. H. K. Paetzold. *Naturwissenschaften*, **41**, *No.* 14, 318–22 (1954) *In German.*

Fluctuations of the seasonal distribution of O_3 with height are discussed with reference to meteorological conditions existing in the lower and middle atmosphere. The date of the seasonal max. of O_3 concentration varies with altitude, being nearly 90° out of phase at heights >30 km compared with that for the altitude range, 20–25 km. Above 30 km the max. occurs in summer, and is due to the photochemical action of solar u.v. radiation. Between 20 and 15 km the max. concentration found during the summer is probably due to enhanced atmospheric turbulence at these heights. In the zone, 25 to 30 km neither photosynthesis, nor convective processes operate; consequently no marked seasonal change is found. Below 20 km a pronounced max. concentration in spring results from advective movement of polar O_3 towards lower latitudes. D. R. BARBER

551.510.535

11593. An explanation of radio propagation at 16 kc/sec in terms of two layers below *E* layer. R. N. Bracewell and W. C. Bain. *J. atmos. terrest. Phys.*, **2**, *No.* 4, 216–25 (1952).

An ionospheric model consisting of two ionized layers below the normal *E* layer is postulated in an attempt to account for observed features of the propagation of 16 kc/s radiowaves over distances of 90 and 535 km. These observations suggest the existence of more than one ionized layer below the *E* layer. The lower of the two postulated layers reflects very long waves over the 535 km range, but over 90 km this layer is penetrated and the waves are reflected from the upper layer. The field produced by a transmitter at distances up to about 300 km is composed of the ground wave plus waves reflected one and more times from the upper layer. At 535 km, waves from both layers contribute to the total field, especially the wave reflected once from the lower layer and waves reflected more than once from the upper layer. New experimental data for 535 km are interpreted in terms of this model. A.

551.510.535

11594. Theory of formation of an ionospheric layer below *E* layer based on eclipse and solar flare effects at 16 kc/sec. R. N. BRACEWELL. *J. atmos. terrest. Phys.*, **2,** *No.* 4, 226–35 (1952).

The height of reflection of 16 kc/s waves from the ionosphere at steep incidence was carefully observed during the partial solar eclipse of April 28, 1949, and a symmetrical anomaly was found. This observation, and the observed effects of solar flares, are shown to be incompatible with the theory that reflection takes place from the bottom of a Chapman layer. An alternative mechanism is proposed whose essential feature is the removal of the restriction in the Chapman theory that the electron density should be negligible compared with the density of ionizable particles. The resulting theory is worked out. In the extreme case of virtual exhaustion of the supply of ionizable particles in the top of the ionized layer, an increase in the incident ionizing radiation simply lowers the lower boundary of the layer. The consequences of this sort of behaviour are in agreement with observation as regards (i) the eclipse effect, (ii) the effect of solar flares and (iii) the diurnal variation of height. A.

551.510.535

11595. The morphology of storms in the *F*2 layer of the ionosphere. I. Some statistical relationships. E. V. APPLETON AND W. R. PIGGOTT. *J. atmos. terrest. Phys.*, **2,** *No.* 4, 236–52 (1952).

The results of a statistical study of ionosphere storm phenomena at a number of stations are described. These have revealed a marked diurnal control of storm manifestation accountable only in terms of station local time. The different average sequences of storm events at auroral, temperate and equatorial latitudes are contrasted, and it is shown that, in temperate latitudes at least, such sequences display a seasonal variation. A.

551.510.535

11596. The graphical representation of the longitude effect in *F*2 region. C. M. MINNIS. *J. atmos. terrest. Phys.*, **2,** *No.* 5, 261–5 (1952).

Assuming that the type of $fF2$/dip angle relation suggested by Appleton is valid, a network of geographical zones can be constructed within each of which the change of $fF2$ along a line of latitude does not exceed some upper limit. A typical set of zones has been constructed but the boundaries are too complex and variable to be used in practice for the accurate representation of the geographical distribution of $fF2$. It is concluded that for commercial use the best method would be to make use of a set of hourly charts each of which would show the distribution at a fixed U.T. A.

551.510.535

11597. Theoretical group heights of reflection of 150 kc/s radio waves vertically incident on the ionosphere. N. DAVIDS. *J. atmos. terrest. Phys.*, **2,** *No.* 6, 324–36 (1952).

The theoretically expected group heights for 250 μsec Gaussian shaped pulses are determined utilizing: (1) a wave-theory treatment including coupling, (2) a Chapman-like ionospheric model including all variables and their height variations and (3) a fundamental radio-frequency or carrier component of 150 kc/s. From the theoretical viewpoint the continuous wave (c.w.) results of Gibbons and Nertney are extended by including the dispersive characteristics of the above model. This is accomplished by determining the received pulse characteristics by means of a response function developed from a suitable Fourier–Hermite series which includes the frequency dependent effects of the model. It is found that the rapid changes in polarization near the lower edge of the *E*-region, called the "coupling region," are very effective in generating reflected waves or pulses under suitable conditions, i.e. late night hours associated with low *E*-layer critical frequencies. However, the dispersive characteristics are small so that almost negligible group retardation is to be expected. At a higher level in the layer rapid variations in the index of refraction for one of the characteristic wave components occur in what is called the "reflection region." Here the time-delays are large for low critical frequency models. Some geometrical discussion is included concerning polarization and coupling factors. If properly considered, the ordinary and extraordinary modes can be given a representation (in a certain complex space) as orthogonal principal directions. The above theory is compared with the experimentally observed group heights on a diurnal basis. Good agreement is obtained and is further strengthened by comparison with some recent measurements of R. E. Jones on the diurnal change in phase (c.w.) paths. A.

551.510.535

11598. Solar ionospheric tides in the *F*2 region. A. A. WEISS. *J. atmos. terrest. Phys.*, **3,** 30–40 (*Jan.*, 1953).

The equation of continuity for electrons subject to the influence of a vertical drift harmonic in time has been integrated by numerical methods, taking the processes of ion-production and recombination into account, for physical conditions representative of the *F*2 region. The method of solution is quite general, and the treatment embraces both drift velocities and recombination coefficients which may be either uniform or non-uniform with height. The adequacy of published solutions of the continuity equation, in which ion production and usually also recombination are neglected, is examined and it is concluded that the neglect of these processes is justifiable in an initial survey of *F*2 solar tidal data. The results of the analysis are applied to a brief discussion of the nature of the information regarding the vertical electron drift which can be derived from measured ionospheric data. A.

551.510.535

11599. Some practical determinations of the electron content below the level of maximum ionization in the *F*2 region of the ionosphere. B. W. OSBORNE. *J. atmos. terrest. Phys.*, **3,** 58–67 (*Jan.*, 1953).

Describes an investigation of the variation in the total number of electrons, n, in a vertical column of unit cross-section in the *F*2 region of the ionosphere up to the level of maximum ionization with the solar zenith angle χ at Slough and Singapore during selected days in every month of 1949; and at Singapore and

Penang during a programme of simultaneous observations made at the two stations in July, 1949. The seasonal and diurnal variations of maximum electron density differ from those in *n*, the latter showing a greater dependence on cos χ. Several anomalies are, however, still evident. Diurnal variations in the latitude gradient of *n* near the magnetic equator are briefly discussed. It appears probable that, as the latitude is altered, the local noon value of *n* goes through a flat maximum in equatorial latitudes, whereas the noon value of maximum electron density goes through a sharp minimum near the magnetic equator, and exhibits the well-known "equatorial trough." A.

551.510.535

11600. Electronic density of the upper atmosphere and interpretation of the curve *h′*(*f*) of the virtual height of the ionosphere. F. Mariani. *Ann. Geofis.*, **6,** 21–45 (*Jan.*, 1953) *In Italian.*

The group refractive index, relative to the vertical propagation of an electromagnetic wave in the ionosphere is calculated for the latitude of Rome, using the exact formula first given by Appleton, considering the influence of the magnetic field but neglecting the absorption determined by the electron impacts. The "optical path" corresponding to a wave of given frequency *f*, which penetrates a "parabolic" layer and either crosses it or is reflected by it is also calculated. A method is developed for comparing the experimental curve of the virtual height *h′*(*f*) with the theory in order to determine, in a general manner, the geometrical parameters of the electronic distribution in ionospheric layers; redrawing the experimental *h′*(*f*) curves the thickness z_0 of every layer and its height above ground level are obtained directly considering both the cases of totally separated and of partially superposed layers. This method of analysis is being used in order to study the characteristics of the ionosphere in Rome, for comparison with geomagnetic and solar data. A.

551.510.535

11601. Electronic density of the upper atmosphere and interpretation of the curve *h′*(*f*) of the virtual height of the ionosphere. II. F. Mariani. *Ann. Geofis.*, **6,** 533–53 (*Oct.*, 1953) *In Italian.*

The "optical path" is calculated for an electromagnetic wave which penetrates and is reflected by a Chapman layer having a "semithickness" $2{\cdot}5H$ (H = scale height): a comparison of the results with those obtained in Pt I shows that such a model is well approximated in its lower half by a parabolic layer of semithickness $z_0 = 1{\cdot}5H$. The inadequacy of the method of analysis of the ionograms explained in Pt I, for those ionograms in which the F_1 and the "true" F_2 layers are partially superposed, is ascertained. The electronic density distribution is studied in the superposition region considering the recombination of the electrons and the ions and it is shown that the model of linear superposition used in Pt I must be replaced by a more complicated model in which the electronic density is $N = [N_1^2 + N_2^2]^{1/2}$ (N_1 and N_2 are the densities of the F_1 and the "true" F_2 layers if they are independent). A preliminary comparison of the theoretical and experimental results seems to give a better interpretation of the ionograms. A.

551.510.535

11602. Moving clouds of ionisation in region *E* of the ionosphere. J. W. Findlay. *J. atmos. terrest. Phys.*, **3,** 73–8 (*Feb.*, 1953).

The paper describes determinations of the velocities of movement of clouds of ionization in the lower part of region *E* of the ionosphere. Observations were made during a period of three years with a pulsed transmitter and a receiver operating on a frequency of 2·4 Mc/s, and in the course of these observations 110 echoes were seen from the lower part of the *E* layer. These echoes lasted for periods from one minute to about twenty minutes, and they are interpreted as coming from discrete clouds of ionization. The manner in which the phase paths of these echoes changed with time suggests that the clouds were moving with velocities between 20 m/sec and 150 m/sec. The durations of the echoes are shown to be inversely proportional to the velocities of the clouds and from this it is deduced that an average cloud was a few hundred metres in size in the horizontal plane. A.

551.510.535

11603. The heights of ionospheric winds as measured at long radio wavelengths. R. E. Jones, G. H. Millman and R. J. Nertney. *J. atmos. terrest. Phys.*, **3,** 79–91 (*Feb.*, 1953).

A method is developed for obtaining the heights at which ionospheric winds, as measured at long radio wavelengths, occur. This involves augmenting the usual winds measurements with recordings of the changes in phase path. The necessary theory for diffraction by a phase-amplitude screen is developed. Several numerical examples are presented for sinusoidal phase-amplitude screens. Finally, seventy days of data are analysed. It is shown that the daytime winds, measured at 150 kc/s, probably occur around the 75 km height level and the night-time winds probably occur in the 83 to 100 km range. A.

551.510.535

11604. On the comparative increases of the *F*1 and *F*2 ionizations from sunspot minimum to sunspot maximum. M. Ghosh. *J. geophys. Res.*, **58,** 41–51 (*March*, 1953).

Ionospheric records show that between the epochs of sunspot minimum and sunspot maximum the ionization of the *F*2 region increases by a much larger factor than the ionizations of the *E* and *F*1 regions (by a factor of about 3 for *F*2 maximum and a factor of about 1·6 for the *F*1 maximum). This anomaly can be explained on a proper consideration of the current hypothesis of the formation of the composite *F* region. According to this hypothesis, there is only one ionizing radiation (ionizing atomic oxygen) for the composite *F* region. *F*1 is formed, at a height where the rate of ion production is maximum, by the usual Chapman process, and another bank of ionization with greater ionization density appears at a greater height, as a result of rising temperature and falling (effective) recombination coefficient above *F*1 maximum. In the present paper, the ionization distribution of the composite *F* region with height is calculated with the help of the formulae derived by Mitra [Abstr. 2843 (1953)]. It is found that a comparatively small increase in *F*1 ionization (due to an increase in the ionizing radiation) leads to a much larger increase in the $F2$ ionization. The increase of $F2$ ionization from sunspot minimum to sunspot maximum, as calculated, is found to agree well with that as observed. A.

551.510.535

11605. The collision frequency of electrons in the ionosphere. M. NICOLET. *J. atmos. terrest. Phys.*, **3**, 200–11 (*May*, 1953).

Theoretical analysis shows that the electron collision frequency in the ionosphere depends on the neutral particle concentration in regions D and E and on the electron concentration in region F. Any atmospheric model above the E layer cannot, therefore, be based on the electron collision frequency with neutral particles. A.

551.510.535

11606. Method of determination of the true heights of the layers of the ionosphere, taking into account the action of the terrestrial magnetic field. I. Use of an approximate expression for the index of refraction (case of the ordinary ray). E. ARGENCE AND M. MAYOT. *J. geophys. Res.*, **58**, 147–65 (*June*, 1953) *In French.*

New relations for the characteristic parameters of an ionospheric region when the ionization follows the parabolic law are obtained. Results are compared with those obtained by Appleton's method, and an important corrective term for the value of the layer's thickness is obtained, in good agreement with that indicated by Shinn and Whale. The mathematical terms representing action of the earth's magnetic field always act to make smaller the value of the thickness evaluated according to classical methods (Appleton, Pekeris, Rydbeck). A.

551.510.535

11607. Method of determination of the true heights of the layers of the ionosphere. II. Use of the exact value of the refractive index (case of the ordinary ray). E. ARGENCE AND M. MAYOT. *J. geophys. Res.*, **58**, 493–6 (*Dec.*, 1953) *In French.*

Determination of the characteristic parameters of an ionized layer by the hypothesis where the variation of the electronic density ensues from a parabolic law, to the first approximation, is described. The application of the exact value of the refractive index (Appleton–Hartree) is also shown. A.

551.510.535

11608. Nature and origin of sporadic E regions as observed at different hours (over Calcutta). B. CHATTERJEE. *J. atmos. terrest. Phys.*, **3**, 229–38 (*June*, 1953).

Describes the results of measurement on the variation of reflection co-efficient of the sporadic E echoes and of the statistical study of the variations of amplitude of the same, carried out, over a period of 8 months (March to October, 1952). It has been possible from these measurements and studies to discriminate between two types of E_s ionizations—thin layer type and ion cloud or blob type—causing the echoes. It was found that there is predominance of different types of ionizations at different hours of day and night. Thus in 78·6% of the cases observed in the early morning hours, the E_s ionization was of the cloud or blob type of structure. It is suggested that this type owes its origin to ionization by sporadic meteors which are most frequent in the early morning. During the period of sunrise in the E layer, thin layer type of ionization were found in 83·7% of the cases. Such ionization is probably caused by the production of a sharp ionization density gradient at the bottom of the E layer, due to photo-detachment of electrons from negative ions of O and O_2 by sun's rays coming from below the horizon. The most common type of E_s ionization in the afternoon and evening hours was found to be a mixture of the thin layer and ion cloud types. These owe their origin to travelling ion clouds coming from above. Observations also showed that E_s ionization (of the mixed type, with a slight preponderance of the thin layer type) was associated with thunderstorms. Blanketing types of E_s are also observed during thunderstorms. Occasionally, some thin layer types of ionizations were also observed in the morning, a few hours after sunrise. The origin of these ionizations seems to be due to some modifications of the E layer structure. A.

551.510.535

11609. The distribution of $F2$ region ionization at high latitudes. J. C. W. SCOTT. *J. atmos. terrest. Phys.*, **3**, 289–94 (*July*, 1953).

The geographical distribution of $foF2$ in the arctic is analysed by the use of polar contour charts of zero intercept and slope in the linear relation $foF2 = a + bs$, between the critical frequency and the sunspot number. The distribution is found to be dependent on the geomagnetic field and the auroral zone. A.

551.510.535

11610. Study of the ionospheric D region using partial reflections. F. F. GARDNER and J. L. PAWSEY. *J. atmos. terrest. Phys.*, **3**, 321–44 (*July*, 1953).

Observations are described which show that by using the high sensitivity possible at a low-noise receiving site, echoes at vertical incidence can be regularly observed by day down to heights of about 60 kilometres on 2 Mc/s. A new method has been developed for determining electron density and collision frequency from observations of such echoes. It is based on the distinctive behaviour of the two magneto-ionic components. At a given time the ratio of the two is a function of height alone. This is explained in terms of differences in partial reflection coefficients at the place of reflection together with differential absorption below. The observations show that the part of the ionosphere below the normal E region consists of two distinct parts: (*a*) A region at about 70 kilometres where distinct strata form by day, and (*b*) a region of greater electron density at about 90 kilometres which extends up to the normal E region. The lower region has maximum ionization at midday and disappears at night but does not show a progressive height change; the upper extends downwards to nearly merge with the lower at midday and rises at night but does not disappear. It is the one chiefly responsible for medium and short wave attenuation. A.

551.510.535

11611. Dissociative recombination in the E-layer. E. GERJUOY AND M. A. BIONDI. *J. geophys. Res.*, **58**, 295–303 (*Sept.*, 1953).

Discusses the consequences of the assumption that dissociative recombination determines electron removal in the E-layer. The observation that the apparent recombination coefficient, α, does not depend markedly on the altitude of the *E*-layer, electron density or time of day imposes restrictions on the rates of the various atomic collision processes. It is shown that α must be very nearly equal to the actual dissociative recombination coefficient of O_2^+ ions and electrons. The conversion of O^+ to O_2^+ by charge transfer is consistent with ionospheric observations provided that the transfer cross-section is $\gtrsim 10^{-17}$ cm². In addition, the negative ion concentration is required to remain smaller than the electron concentration at all times. It is concluded that dissociative recombination is far more satisfactory than ion-ion recombination in explaining the *E*-layer observations, and that most of the atomic processes proposed for this mechanism are subject to accurate laboratory measurement. A.

551.510.535

11612. Propagation measurements in the ionosphere, with the aid of rockets. J. C. Seddon. *J. geophys. Res.*, **58**, 323–35 (*Sept.*, 1953).

Daytime rocket measurements of electron density, ion density, electron collision frequency and earth's magnetic field in the ionosphere were made in New Mexico. Two CW harmonically related frequencies were radiated from the rocket to two ground stations to obtain measurements of the ordinary and extraordinary indices of refraction in the region around the rocket. The results for one flight show an ion layer with a maximum of 5×10^8 ions/cm³ and a small electron layer with a maximum of 7500 el/cm³ just below the *E*1-layer. On a September day the *E*1-layer remained dense up to the *E*2-layer, while on a January day the density apparently decreased above the *E*1-layer maximum to much lower values. It is shown that the Lorentz polarization term should not be used in the *E*-layer at 4 Mc/s. A.

551.510.535

11613. Irregularities in the ionosphere. R. Roy and J. K. D. Verma. *J. geophys. Res.*, **58**, 473–85 (*Dec.*, 1953).

Electron clouds, both in the *E* and *F* regions of the ionosphere, have been detected at vertical incidence by means of a high-precision ionosphere sounding equipment. The clouds give rise to scattered echoes, which are delineated on an expanded sweep as individual pips, resolved out from the normal echoes. An estimate of the received power by back-scattering, made on the basis of the theory of tropospheric radio scattering by Booker and Gordon, shows that it is far in excess of the receiver noise power. Some of the records indicate that sometimes at night the normal layer structure of the ionosphere ceases to hold; the ionospheric regions then contain only electron clouds at different heights. The scattered echoes generally appear for a very short duration. The short persistence (1 to 2 min) of these echoes has been explained by considering the drift of the clouds by the upper air winds. A.

551.510.535

11614. The determination of the electron density distribution of an ionosphere layer in the presence of an external magnetic field. J. M. Kelso. *J. atmos. terrest. Phys.*, **5**, 11–27 (*March*, 1954).

An accurate method is given for the determination of the electron density distribution of an ionosphere layer in the presence of an external magnetic field. The shape of the layer is determined in the process of calculation, and is not assumed in advance. Estimates of the thickness and height of the maximum ionization of a layer made by determining the electron density distribution using techniques which neglect the magnetic field are too great by 15 to 20%; i.e. in place of a correct scale height of 8 km, such methods yield a scale height of nearly 10 km. A careful application of the present procedure reduces such overestimation to 2 or 3%. Methods which assume a particular form of layer, usually parabolic, are subject to great possible errors, depending upon the degree to which the actual layer departs from parabolic form. When the magnetic field is neglected, the errors in thickness found in this way can be too large by a factor of two or three. Even when the magnetic field is considered, such methods can give thicknesses in error by a factor of as much as two. These methods usually give values of the height of maximum ionization which are much better than the values they yield for the thickness. This, however, may depend upon accidental fluctuations in the group path curve. In the present paper, the electron density distribution is determined by finding the actual heights at which waves of various frequencies are reflected. These true heights are obtained from experimental *h′-f* curves by obtaining the exact solution, as a convergent series of integrals, of the integral equation giving the group height as a function of frequency. The errors arising in the numerical work are shown by applying the procedure to *h′-f* curves obtained theoretically from layers of known shape, and such errors are seen to be small compared with those made through use of other procedures. A.

551.510.535

11615. Some results of sweep-frequency investigation in the low frequency band. J. M. Watts and J. N. Brown. *J. geophys. Res.*, **59**, 71–86 (*March*, 1954).

Sweep-frequency techniques, long in use in high-frequency ionospheric research, have been used recently in low frequency research at the National Bureau of Standards. The discovery of a night-time layer between the *E*- and *F*-layers, which is erratic in appearance, but which seems to have continuity with the daytime *E*-layer during sunset, is reported. Traces characteristic of magneto-ionic splitting are exhibited for the new layer and also for the low-level *E*-layer. Polarization and virtual height records of *F*-layer at night are shown and the effects of ionosphere storms on *E*- and *F*-regions are demonstrated. Daytime reflections have been recorded from three distinct *E*-region boundaries, each of which appears to be quite sharp in ion gradient. These extend from about 70 km to over 100 km in virtual height. Several recordings of turbulent conditions in the lower levels of the daytime *E*-region are shown. A.

551.510.535

11616. Observations on the propagation of very long radio waves reflected obliquely from the ionosphere during a solar flare. W. C. Bain. *J. atmos. terrest. Phys.*, **3**, 141–52 (*April*, 1954).

A discussion is given of the general appearance of anomalies in the field of GBR (16 kc/s) during solar flares, when observations are made at distances from the transmitter of 400–550 km. It is shown that the main effect is due to a sky wave reflected once from the ionosphere varying in phase but not in amplitude. An explanation of the size of anomaly found at these distances is given in terms of two layers below the *E* layer of the ionosphere. The layer which is usually the lower of the two is that normally responsible for oblique incidence propagation, and the other is that which is affected by the solar radiation during a flare. The timing of the oblique incidence anomaly is also discussed. A value of 70 km for the apparent reflection height of the layer responsible for the reflection of 16 kc/s radiowaves at oblique incidence is obtained with the aid of the field strength changes noted during these anomalies. A.

551.510.535

11617. 27 day variations in the absorption of the *D* region of the ionosphere over Singapore and Slough. G. Lange-Hesse. *J. atmos. terrest. Phys.*, **3**, 153–62 (*April*, 1954) *In German.*

The absorption in the *D*-layer of the ionosphere is already known to change with the seasons and with the 11-year sunspot cycle. The question has therefore been examined, whether analogous variations occur in the course of the solar rotation of about 27 days in cases where the sunspots are unequally distributed in heliographic longitude (in such cases the sun exhibits, in the course of a rotation, alternatively aspects with many spots and with few spots). Such variations in absorption of appreciable amplitude are found at Singapore during the whole year, at Slough (near London), however, only during the summer months. Other variations in absorption of larger amplitude than in summer are found in Slough during the winter months, but these winter-time variations are not controlled by 27-days variation in sunspot number *R* and also not by variations in particle radiation. The significance of these results in connection with radiocommunication circuits and for ionospheric forecasting is briefly discussed. A.

551.510.535

11618. Atomic nitrogen as a constituent for region *F*1. A. P. Mitra. *Indian J. Phys.*, **28**, 269–84 (*June*, 1954).

The case of atomic nitrogen as one of the possible constituents for region *F*1 is studied by examining simultaneously the problem of dissociation of molecular nitrogen and that of the ionization of the resulting nitrogen atoms. The dynamic condition of the atmosphere is taken into account. It is shown that the maximum of ionization produced as a result of photoionization of atomic nitrogen lies between 150 to 200 km, for overhead sun, the best value being somewhere around 170 km. Further, to give adequate ionization for the *F*1-layer, the concentration of atomic nitrogen at the height where diffusive separation takes place need not be larger than $\frac{1}{10}n(N_2)$. Possible contribution from the ionization of atomic oxygen at third ionization potential is also discussed. A.

551.510.535

11619. Group height calculations in the presence of the earth's magnetic field. J. M. Kelso. *J. atmos. terrest. Phys.*, **5**, 117–31 (*July*, 1954).

A method is given for the computation of an *h′-f* curve for an ionosphere of arbitrary shape. The effects of the earth's magnetic field may be included. The method is based on integral formulae involving the derivative of height with electron density, dz/dN, and misbehaviour of this derivative curve leads to inaccuracies in the results. The two integral formulae used are obtained as special cases of the Gauss-Christoffel quadrature formula. The procedure is applied to: (1) a linear layer; (2) a parabolic layer; (3) a cosine layer; and (4) an arc-cosine layer. The first three cases are studied with and without the earth's magnetic field, and the results of the first two are compared with exact calculations by other workers. The cosine layer results are compared with those for a Chapman layer. The arc-cosine layer shows a maximum in the *h′-f* curve which does not correspond to any prominent feature of the electron density curve, showing a need for care in the study of *h′-f* curves. A different method is given for the calculation of an *h′-f* curve in the case of penetration of a layer of arbitrary shape. A.

551.510.535

11620. Ionospheric absorption measurements during a sunspot cycle. E. Appleton and W. R. Piggott. *J. atmos. terrest. Phys.*, **5**, 141–72 (*July*, 1954).

The results of a comprehensive series of observations on the absorption of radio waves during the process of ionospheric reflection are described. Such observations have included experimental studies of the dependence of atmospheric absorption $|\log \rho|$ (ρ being the effective ionospheric reflection coefficient), on the radiowave frequency f, on solar zenith distance χ and on solar activity as expressed by the sunspot number *R*. For the last-mentioned purpose the time-series of comparable observations has extended over a period of nearly two sunspot cycles. It is found that the variation of $|\log \rho|$ with f is adequately explained by the magneto-ionic theory of ionospheric dispersion and absorption, provided that $\nu^2 \ll (f + f_L)^2$, where ν is the electron collision frequency and f_L is the gyro-frequency corresponding to the vertical component of the geomagnetic field. On the other hand, the dependence of $|\log \rho|$ on $\cos \chi$, examined either diurnally or seasonally, is found to be irreconcilable with simple theory if ν is so restricted and the absorbing layer is formed in an isothermal atmosphere of uniform composition in which the electron recombination coefficient is independent of pressure. Such a simple theory predicts that $|\log \rho|$ should be proportional to $(\cos \chi)^n$ where n is $1 \cdot 5$, whereas some hundred diurnal examinations of this relationship yield an average value for n of the order of $0 \cdot 75$. Possible explanations of this discrepancy are that the electron recombination coefficient falls off to some extent with increasing height and that the temperature of the absorbing stratum is not uniform, but increases upwards. It seems, however, clear that the removal of electrons from the absorbing layer cannot take place by way of a process described by an attachment law. Seasonal studies of the dependence of $|\log \rho|$ on $\cos \chi$ have confirmed the existence of a winter anomaly, which has been evident during the months of November to February ever since the series of observations was started in 1935. This winter anomaly is characterized by the occurrence of excessive absorption on certain groups of days during the months mentioned, a phenomenon which is not paralleled during the rest of the year. A statistical study shows that the occurrence of these days of high absorption is directly correlated with the occurrence of sporadic reflecting strata below the level of the *E* layer. A series of noon measurements of absorption, of eighteen years' duration, has demonstrated a general direct correlation of $|\log \rho|$ with sunspot number *R*. Sunspot-cycle control is, however, more evident in summer than in winter. Various lines of evidence emerging from the experimental results show that the absorbing stratum must be located below the *E*-layer, and the general conclusion reached is that it lies within the *D*-region. Arguments are also advanced for concluding that the *D*-layer cannot be the seat of the currents responsible for the quiet-day solar magnetic variations S_q; while other considerations indicate that the layer of temporarily enhanced ionization caused by solar flares can, likewise, not be identified with the S_q current layer, as has previously been widely supposed. It does, however, seem most probable that sudden ionospheric disturbances associated with solar flares are due to augmentations of ionization in the normal absorbing layer, the ionization density being increased there by a factor of from 5 to 10. A.

551.510.535

11621. On the interpretation of the apparent ionization distribution in the ionosphere. W. R. Piggott. *J. atmos. terrest. Phys.*, 5, 201–10 (*Sept.*, 1954).

Methods of deducing the highest and lowest ionization distributions which are consistent with a given *h′f* pattern are indicated and the sources of error when using rapid methods of analysis are briefly discussed. Some examples are given. A.

551.510.535

11622. A monochromatically ionized layer in a non-uniformly recombinant atmosphere; with applications to the *D* and *E* ionospheric regions. S. Chapman. *Proc. Phys. Soc.* [*London*] *B*, **67**, 717–27 (*Sept.*, 1954).

Ionization of an exponential atmosphere by monochromatic solar radiation is considered when the recombinance α is not independent of height but varies as $\alpha_0 + \alpha_1 e^{-bh}$, where α_0, α_1, and *b* are constants. A recombinance datum level is defined, namely the level where α_0 and $\alpha_1 e^{-bh}$ are equal: heights are measured from this level, in scale-height units. The level of the absorption peak being z_χ (when the sun's zenith distance is χ, or z_0 when $\chi = 0$), the level z_m of the electron peak and the height distribution of the electron density n_e are considered, for different values of z_0 and of $c(=b/H)$, particularly $c = 1, 2, 3$. When $c > 0$ the electron peak is always above the absorption peak, and for $c \geqslant 2$ it is always above the recombinance datum level: the electron peak for $c = 1$, when the absorption peak is below the recombinance datum level, is about half-way between the two. The decrease of n_e (from its maximum value n_{em}) on the underside (or incline) of the electron layer can be much less steep than for a Chapman layer, if the absorption peak is below the recombinance datum level. The results for the model atmospheres considered are tentatively discussed with reference to the *E* and *D* ionospheric regions, but their potential value may be realized only when better data for the *D* region become available. A.

551.510.535 : 551.508.99

11623. Peak amplitude recorder for investigation on fading. S. C. Mazumder and S. N. Mitra. *Indian J. Phys.*, **28**, 251–5 (*June*, 1954).

On pulsed transmissions, the different order ionospheric returns are received at distinct time intervals and they are represented as separate echoes. This paper describes an experimental arrangement which can select any one of these "echoes" and record its amplitude variation. A.

551.510.535 : 523.165

11624. Ionospheric refraction of 81.5 Mc/s radio waves from radio stars. F. G. Smith. *J. atmos. terrest. Phys.*, **2,** *No.* 6, 350–5 (1952).

Ionospheric refraction of radiowaves from radio stars may cause variations in the apparent right ascensions of the stars because of horizontal gradients in the total ionization of the ionosphere. These gradients occur during the normal diurnal changes of the *F*-region, and observations of their magnitude allow an estimate to be made of the total ionization of the *F*-region, including the part above the maximum of ionization density. An account is given of measurements of the refraction of 81·5 Mc/s radiowaves from four radio stars. The results are compared with calculations made from the results of ionospheric soundings, and they are found to be in agreement if certain plausible assumptions are made about the distribution of electrons in the *F*-region. A.

551.510.535 : 523.722

Scintillations of radio stars due to ionospheric fluctuations. *See Abstr.* 10765–6

551.510.535 : 523.745

11625. Some statistical results on the phenomena associated with ionospheric storms. D. W. G. Chappell, L. B. Hainsworth and I. M. Moorat. *J. atmos. terrest. Phys.*, **3**, 301–20 (*July*, 1953).

A statistical examination is made, in relation to ionospheric storm production and duration, of the effects of sunspots, *M*-regions and solar flares on the critical frequency (f_0F2) and height of maximum ionization (*hm*) of the *F*2-layer of the ionosphere and of the absorption (*A*) in the lower layers. An ionospheric storm day is defined as one in which the mean change in any of these parameters is such as to cause a 10% decrease in the mean maximum usable frequency (M.U.F.) or a 10% increase in the lowest usable high frequency (L.U.F.) for radio transmission from the value expected for quiet conditions at the place and time of observation. The changes in the probability of any day following a solar event being a storm day are analysed using ionospheric data measured at Slough, during the years 1941–1949. It is concluded that, except for storms associated with *M*-regions at sunspot minimum, the probability that a given day will be a storm day, assessed on changes in f_0F2, does not exceed 0·5 for the first day of a storm but may reach 0·7 on subsequent days. The probability falls below 0·26 four days after an intense Dellinger fade, immediately after a weak Dellinger fade and during the passage of a sunspot in solstice months. The change in the probability of a storm occurring during the passage of a sunspot is inconsistent with a simple theory of particle emission normal to the sun's surface and is dependent on the season and the solar hemisphere in which the spot appears. A.

551.510.535 : 523.78

11626. On some anomalies of the ionospheric critical frequency during an eclipse of the sun. G. Zanotelli. *Ann. Geofis.*, **6**, 367–72 (*July*, 1953) *In Italian.*

The results of the ionospheric soundings carried out in Rome during the partial eclipse of the sun of February 25, 1952, are presented. Three minima were found in the electronic concentration; one before the beginning of the eclipse, one for the maximum phase, and one at the end of the eclipse. It is shown, assuming that the cause of the two extreme minima is to be found in the external zone of the visible part of the solar disk, that one can explain the otherwise inexplicable delay of the last minimum with respect to the visible eclipse, and one can interpret, at the same time, strong apparent variation in the coefficient of recombination of the ionospheric electrons. A.

551.550.535 : 538.566.3

11627. The analysis of fading records from spaced receivers. J. A. Ratcliffe. *J. atmos. terrest. Phys.*, **5**, 173–81 (*July*, 1954).

Deals with the fading of a single radio pulse reflected at vertical incidence from the ionosphere to three receivers on the ground. Records of this fading, made when the three receivers are at the corners of a right-angled triangle, and distant about one wavelength from each other, have often been used in the measurement of ionospheric "winds." It is shown that a "wind" constant both in direction and magnitude could produce a markedly variable record. Two actual records, each lasting one hour, are analysed. One is shown to correspond to an occasion when the "wind" was constant. The other record cannot be explained on such a simple assumption. The need for a more detailed method of analysis is stressed. A.

551.510.535 : 538.566.3

Radio-wave propagation in the ionosphere. *See Abstr.* 11237–47

551.510.535 : 550.384/.385

11628. Diurnal and storm-time variations of geomagnetic and ionospheric disturbance. R. P. W. Lewis and D. H. McIntosh. *J. atmos. terrest. Phys.*, **3**, 186–93 (*May*, 1953).

The geomagnetic and ionospheric diurnal and storm-time variations occurring at Abinger and Slough over a period of 46 months are studied. The diurnal variations are shown to be highly complex, with significant differences appearing in different seasons and at various levels of activity. The 24-hourly component of daily variation is important in both phenomena, but a significant and regular 12-hourly component is observed only in ionospheric (f_0F_2) disturbance. The storm-time variations of f_0F_2 and absolute horizontal magnetic force are found to be statistically closely linked. A.

551.510.535 : 550.384

11629. Atmospheric oscillations at high altitudes and their relation to geomagnetic field variations. R. Pratap. *Proc. Nat. Inst. Sci. India*, **20**, 252–8 (*May–June*, 1954).

The dynamo equations developed in a previous paper (in press) have been used to calculate the S_9 variations in H and V. Assuming different "phases" for the atmospheric oscillations at the ionospheric layer which is possibly the seat of the "Ring Currents," and comparing them with the observed magnetic field variations at different latitudes, it has been shown that a phase of 275° gives the best possible fit. Theoretical estimates of the S_q variations, based on the present analysis, have been obtained for different observatories. "Ring Currents" have also been calculated with different phases, and that too shows that a phase of 275° for the oscillation at about 100 km is the most probable one. A.

551.510.535 : 551.510.41

11630. A tentative model of the equilibrium height distribution of nitric oxide in the high atmosphere and the resulting *D*-layer. A. P. Mitra. *J. atmos. terrest. Phys.*, **5**, 28–43 (*March*, 1954).

An attempt is made to derive a tentative model for the equilibrium distribution of nitric oxide in the height range 50–100 km by considering some of the possible photochemical reactions involving ozone, nitrogen and oxygen (both molecular and atomic) and nitrous oxide. The distribution depends markedly on the types of O and N_2O distributions assumed. In general, under the conditions of photochemical equilibrium, the maximum of NO concentration occurs within 85–95 km with a maximum concentration not exceeding a value of about $2 \times 10^{12}/\text{cm}^3$. The problem of the formation of the *D*-layer by photoionization of NO by L_α is then discussed in some detail. With the NO distributions obtained in this work and the recombination coefficient model given by Mitra and Jones, the process is found to yield adequate ionization for the *D*-layer. A.

551.510.535 : 551.594.12

11631. On the causes of excessive absorption in the ionosphere on winter days. W. Dieminger. *J. atmos. terrest. Phys.*, **2**, *No.* 6, 340–9 (1952) *In German.*

Excessive absorption is observed in the northern hemisphere on groups of days in winter. At the same time echoes are present at heights between 75 and 90 km on frequencies from 1·6 to 4 Mc/s. These echoes show a regular diurnal variation of height with a minimum at noon. They are merging in a level of sporadic echoes at 95 km between sunset and sunrise. The height is independent of frequency. There is a close correlation between the height of the echoes and the absorption of short radiowaves in the ionosphere. It appears that the echoes are produced by a partial reflection at a sharp boundary of an ionized region extending from *E*-layer down to heights between 70 and 90 km. The structure of the echoes points to inhomogeneous ionization. Solar control is apparent but it is unlikely that the daily variation is due to changes of solar radiation. No conclusive explanation is available yet. The echo level at 95 km during night-time is attributed to meteoric dust ionization. A.

551.510.535 : 621.396.11.08

11632. Dynamic probe measurements in the ionosphere. G. Hok, N. W. Spencer and W. G. Dow. *J. geophys. Res.*, **58**, 235–42 (*June*, 1953).

Preliminary rather successful attempts to determine the ionization in the *E*-layer by means of a probe technique are described. The probe current showed an extremely rapid rise between 90 and 105 km altitude. The result indicates a positive-ion density about ten times larger than the electron density. Further measurements with improved equipment are recommended. A.

551.510.536

11633. Physical properties of the atmosphere between ∼80 km and ∼250 km. H. K. Kallmann. *J. geophys. Res.*, **58**, 209–17 (*June*, 1953).

Aims at extending the knowledge of the atmosphere to greater heights by suggesting a set of equations which incorporate some of the physical facts which seem to be known, at least qualitatively. A relation between the fractional change of concentration with change in height is proposed, which gives the possibility of determining the change in molecular weight with altitude, provided a temperature and its gradient are known at a datum level. Molecular weight calculations have been carried out for the region between 80 km and 250 km by assuming molecular oxygen dissociates between ∼80 km and ∼120 km, and molecular nitrogen dissociates between ∼130 km and ∼250 km, assumptions which will be discussed below. The set of equations has been used to calculate pressure and density from 80 km to 160 km, that is, up to an altitude where the calculated values can be compared with the experimental values obtained from rocket results. A rather close agreement between the two sets of data has been obtained. A comparison between the particle density of molecular oxygen and the radiation flux from the sun, responsible for the dissociation of oxygen, has been made and also gives acceptable results. Nevertheless, one may regard this approach as satisfactory only in a semi-quantitative way, because of the rather simple form chosen for the fractional change of concentration with height. A.

551.521.3

11634. Scattering and attenuation by non-spherical atmospheric particles. D. Atlas, M. Kerker and W. Hitschfeld. *J. atmos. terrest. Phys.*, **3**, 108–19 (*Feb.*, 1953).

The approximate theory of Gans for electromagnetic scattering and absorption by ellipsoids is applied to atmospheric particles. It is found that the general form and state of orientation of such particles may be determined, at least in a qualitative manner, from the back-scattered radiation. Spherical particles return radiation polarized like the incident radiation. Non-spherical particles (with some exceptions) give rise to a cross-polarized component. If the particles have preferred orientations, the back-scattered energy depends not only on particle shape but also on the polarization of the radiation and on its angle of incidence. This dependence is more pronounced for water (or water-coated ice) particles than for ice, while snow, on account of its low refractive index, scatters almost like spheres of equal volume, regardless of particle shape or orientation. Randomly oriented shaped particles always scatter and attenuate more strongly than equivolumic spheres; if the particles are oriented, there may be an increase or decrease of their scattering and attenuating powers, depending on their orientation relative to the incident beam. These results in conjunction with Kerker, Langleben and Gunn's calculations (1951) on scattering and attenuation by water-coated ice spheres are shown to be essential constituents of the theory of the bright band (the intense radar echo received from precipitation particles in the process of melting). A.

551.521.3

11635. Seasonal variation in the absorption of solar radiation by atmospheric ozone at 9·6 microns. A. Adel. *Bull. Amer. Meteorol. Soc.*, **35**, 250–2 (*June*, 1954).

A record is presented of the absorption of solar radiation by atmospheric ozone in the interval 9·2–10·1 microns. Seventy-two independent observations made on 70 days are scattered over the various months of the year. The data are suitable for a first examination of the seasonal trend of stratospheric ozone as revealed by an infrared band. The absorptions are reduced to a quantity proportional to the amount of ozone, and the curve of seasonal change in this quantity is strikingly similar to the seasonal trend in ozone as revealed by the long accepted method of ultraviolet absorption. This further usefulness of the 9·6 micron band of ozone as an atmospheric parameter is thus established. A.

551.521.3 : 535.23.08–15

An infrared detector for measurement of the back radiation from the sky. *See Abstr.* 10915

551.551

11636. Turbulence in the upper air, as shown by radar-wind and radiosonde measurements. F. J. Scrase. *Quart. J. Roy. Meteorol. Soc.*, **80**, 369–76 (*July*, 1954).

Observations of the fluctuations, minute by minute, of wind components and temperature in a radiosonde and radar-wind ascent up to 30 km were analysed. After allowing for the effects of random errors a standard deviation of ∼ 4 knots for the eddy velocity, with a mean wind of ∼ 25 knots, was obtained. The standard deviation of the temperature fluctuations was 0·85°F in the troposphere but decreased to about one-third of this in the upper stratosphere. A.

551.557

11637. A radio echo method for the investigation of atmospheric winds at altitudes of 80 to 100 km. J. S. Greenhow. *J. atmos. terrest. Phys.*, **2**, *No.* 5, 282–91 (1952).

The effects of high-altitude winds on the ionized trails produced by meteors are discussed. The variations of wind velocity with height between altitudes of 80 to 100 km can be determined from the fluctuations in amplitude and the changes in width of the radio echoes from the trails. These variable winds are present at all times in the meteor region, and the velocities at points separated by only 5 to 10 km may differ by as much as 50 m/sec. Uniform wind velocities can also be measured by observation of the steady drifts in range of long duration echoes. These uniform winds also have velocities of the order of 50 m/sec. A reversal in the predominant wind direction is observed between 0100 and 0200 hr local time, the direction prior to 0100 hr being roughly from north to south, and after 0200 hr from south to north. A.

551.557

11638. Ionospheric wind analysis by meteoric echo techniques. L. A. MANNING, A. M. PETERSON AND O. G. VILLARD, JR. *J. geophys. Res.*, **59**, 47–62 (*March*, 1954).

The meteoric method for finding the velocities of winds in the lower *E*-region is extended. The previously given procedure for finding vector average wind is shown to be unaffected by the presence of turbulent wind components. A new procedure is worked out for finding root-mean-square values of the horizontal and vertical wind components. By looking at the statistics of the reduction procedures, estimates of the accuracies of the method are found; the sources of error are discussed. Relationships between sample size and accuracy are given. Typical results of the methods are presented. A.

551.557

11639. Winds in the upper atmosphere deduced from the dynamo theory of geomagnetic disturbance. E. H. VESTINE. *J. geophys. Res.*, **59**, 93–128 (*March*, 1954).

Average features of geomagnetic disturbance are represented by atmospheric-electric current-systems. These cannot be uniquely inferred from the magnetic observations at ground level. Using the Balfour Stewart dynamo theory, these electric current-systems are then tentatively replaced by equivalent atmospheric wind-systems, using order of magnitude calculations. It is found that these supposed wind-systems will differ in accordance with the degree of electric polarization of the atmosphere, and with the intensity of toroidal or solenoidal electric currents likely to be present, as a consequence of zonal winds. A simple monthly mean wind-system of geomagnetic disturbance shows good general agreement with a wind-system derived by Kellogg and Schilling from meteorology. A qualitative version of a possible wind-system for the main phase of a magnetic storm is derived and found to show some measure of agreement with diurnal features of atmospheric motions deduced from radio-star scintillations and auroral motions. The causes of such wind-systems, and the effective transverse conductivity of the atmosphere, are briefly but inconclusively discussed. It is shown that the flux of X-rays producing ionization of the *E*-region is apparently the same on days of magnetic storm as on days prior to the storm, and that the dynamo air-flow at the *E*-region yielding the quiet-day diurnal variation also appears inappreciably affected by the presence of a magnetic storm. A.

551.557

11640. The determination of the velocity of winds from spaced fading experiments. G. NEWSTEAD. *J. atmos. terrest. Phys.*, **5**, 182–5 (*July*, 1954).

The statistical variations of radio fading records made at three points are discussed. It is shown what information can be obtained about the statistical variations of the wind-like movements responsible for the fading. A.

551.574.1

11641. Anomalous loss of condensation nuclei in rubber tubing. P. J. NOLAN AND P. J. KENNY. *J. atmos. terrest. Phys.*, **3**, 181–5 (*May*, 1953).

A large non-diffusion loss of condensation nuclei from air drawn through rubber tubing is investigated. The loss is found to be mainly a loss of charged nuclei and appears to be associated with charges produced in the rubber by bending. A summary of a number of important diffusion formulae, one hitherto unpublished, is included. A.

551.576

11642. A laboratory investigation of collision efficiencies, coalescence and electrical charging of simulated cloud droplets. D. SARTOR. *J. Meteorol.*, **11**, 91–103 (*April*, 1954).

A laboratory experiment is described in which liquid drops are formed in a viscous medium to simulate cloud droplets in air by equating the Reynolds number for the experiment to that of the atmospheric case. Certain characteristics of the behaviour of drops of various liquids in different viscous media are described. Collision efficiencies and droplet trajectories differing markedly from previous theoretical calculations are presented for a limited number of drop sizes. The coalescence of water drops falling through mineral oil, and of water drops suspended in air, is found to be a function of the strength of an applied electrical field. An efficient drop-charging process is suggested by the experiment and is proposed as a hypothesis for cloud and thunderstorm electrification. A.

551.578.41 : 548.5

11643. A theory of snow-crystal habit and growth. J. S. MARSHALL AND M. P. LANGLEBEN. *J. Meteorol.*, **11**, 104–20 (*April*, 1954).

Strong evidence, available from the experiments of Nakaya and his co-workers and others, supports the argument that type of snow-crystal growth is determined principally by the excess of the ambient vapour density over that at equilibrium with the ice crystal at its own temperature. Changes in crystal habit occur when this vapour-density excess is sufficient to overcome the inhibitions, first to edge growth and secondly to corner growth, that must exist if the edges and corners have higher surface vapour-densities than the flat faces of the crystal. Equilibrium vapour density for liquid water exceeds that for ice by the order of 10%; slight supersaturation, such as can exist in water cloud, will increase this excess considerably. Ventilation has been neglected in analysing the Nakaya experiments. Its effect was probably slight, since the ventilation was due to natural convection. The effect should be much greater in the atmosphere, where the ice crystal is falling freely. Some such factor must surely be introduced in the case of the natural atmosphere as compared with the laboratory experiments, for with decreasing air pressure the psychrometric values change, and the available vapour-density excess drops off, varying roughly as the cube root of the pressure. The presence of water cloud modifies the diffusion field surrounding an ice crystal, the effect increasing with the size of the crystal. Thus cloud can make a significant contribution to the rate of growth of ice crystals by sublimation. Better spectra of cloud-droplet sizes are needed to evaluate this more fully. A.

551.593.55

11644. A study of sodium in twilight. I. Theory. D. M. HUNTEN. *J. atmos. terrest. Phys.*, **5**, 44–56 (*March*, 1954).

The chemical equilibrium of sodium in the upper atmosphere is shown to lead to a peaked distribution of sodium atoms, the peak coinciding with the transition from O_2 to O. Curves for the intensity of the twilight emission of the *D*-lines are calculated for three model distributions. A study of the ionization of sodium by sunlight suggests that an annual intensity variation similar to the observed one should result, and that any evening-morning intensity difference should be greatest at the equinoxes. A.

551.593.55

11645. A study of sodium in twilight. II. Observations on the distribution. D. M. Hunten and G. G. Shepherd. *J. atmos. terrest. Phys.*, **5**, 58–62 (*March*, 1954).

Observations of the *D*-lines in twilight have been made with a recording auroral spectrometer. When properly corrected, the horizon observations agree with the zenith ones, showing that there is no need to assume a "screening layer" high in the atmosphere for the exciting radiation. Comparison of the observed variation of intensity with curves from Pt I indicate that the density of atomic sodium is a maximum at 85 ± 3 km and falls away exponentially above and below this. The upper part has a scale height of 7·5 ± 2 km to at least 115 km. The shape of the bottom can only be found roughly, but it is similar to that of the top. The peak of the sodium distribution is probably associated with the transition from molecular to atomic oxygen. A.

551.593.9

11646. Note on the origin of night-sky radiations. L. Auberger. *J. geophys. Res.*, **58**, 231–4 (*June*, 1953) *In French*.

Objections can be formulated against the identification of many radiations of the night sky with the Herzberg bands of oxygen. The author states that only five or six can be attributed to the Herzberg system; for the most part those bands probably belong to unknown forbidden systems of nitrogen (several are pointed out). A.

551.593.9

11647. The effect of atmospheric scattering and ground reflection upon the determination of the height of the night airglow. E. V. Ashburn. *J. geophys. Res.*, **59**, 67–70 (*March*, 1954).

Chandrasekhar's theory of radiative transfer is used to calculate the effect of atmospheric scattering and ground reflection upon the determination of the height of the night airglow when the extinction coefficient is 0·15. It is found that the atmospheric scattering is a significant factor, but that the ground reflection is not important except for high albedo (snow cover). A.

551.593.9

11648. The diurnal variation of [O I] 5577 in the nightglow: geographical studies. F. E. Roach, D. R. Williams and H. B. Pettit. *J. geophys. Res.*, **58**, 73–82 (*March*, 1953).

In the region from north latitudes 36° to 44°, the nightglow radiation [O I] 5577 has been reported to undergo a diurnal change in intensity, resulting on the average in an intensity maximum approximately one hour after local midnight. The amplitude of the maximum is such that it is 1·3 times the mean intensity for the entire night. Marked departures from this average variation are noted on individual nights. Two simultaneous sets of observations at Cactus Peak in California and at the Haute Provence Observatory in France are studied in order to compare the diurnal variations at stations with a large difference of longitude. It is found that the variations have similar patterns in general, but with significant differences in detail. On two occasions, approximate triangulations on emission maxima yield a height of 180 km. Attention is called to a similarity between the diurnal variation of the nightglow 5577 at low latitudes and of the polar aurora at high latitudes. A.

551.593.9

11649. Simultaneous observations of nightglow 5577 at two stations. F. E. Roach, D. R. Williams, P. St. Amand, H. B. Pettit and R. G. Weldon. *Ann. Astrophys.*, **17**, 172–85 (*May–June*, 1954).

Observations of [O I] 5577 in the nightglow at Sacramento Peak, New Mexico, and Cactus Peak, California, are recorded for the night of August 9–10, 1953. The great circle distance between the two stations is 1160 km. The difference of latitude is 3° 18′ and of longitude 12° 0′ or 0 hr 48 min. The brightness of the radiation undergoes a time variation which is markedly similar at the two stations. The hypothesis that the variation is primarily a function of local time is supported. The observations indicate that the emitting region produces different integrated brightnesses when viewed from different directions suggesting that it is not a symmetrical layer at a constant height. The observations near the middle of the night can be explained in terms of an asymmetrical fold in an emitting layer. A.

551.593.9

11650. Simultaneous observations of nightglow 5577 at two stations. E. Manring, P. St. Amand, H. B. Pettit, F. E. Roach, D. R. Williams and R. G. Weldon. *Ann. Astrophys.*, **17**, 186–96 (*May–June*, 1954).

A general feature of all the nights of observation at both stations is the occurrence of an intensity maximum on the average two hours before midnight. The general variation resulting in this maximum is a function of the local time. Sporadic changes in intensity are superimposed on the diurnal variation. A.

551.593.9 : 535.338.4

11651. The spectrum of the night sky from 3380 to 4200 Å. M. Dufay. *C.R. Acad. Sci.* [*Paris*] **239**, 533–5 (*Aug.* 18, 1954) *In French*.

Spectrograms obtained with a uviol-glass prism spectrograph reveal in emission the Herzberg $O_2(^3\Sigma_u^+ \rightarrow {}^3\Sigma_g^-)$ bands, N_2^+ bands of variable intensity, and certain other radiations not yet identified, but probably present in Herzberg's $^1\Sigma_u^- \rightarrow {}^3\Sigma_g^-$ emission spectrum. A weakening of the emission bands in March–April allows the Fraunhofer absorption spectrum (residual sunlight) to appear. D. R. BARBER

551.594.11

11652. The atmospheric electric potential drop and the vertical current at Uppsala. H. Norinder, H. Israël and R. Siksna. *Ark. Geofys.*, **2**, *Paper* 6, 109–38 (1954) *In German*.

Describes the location and apparatus of a new station together with the results for the first year from

August, 1950 to August, 1951. The data is given in 7 tables giving mean values for the different hours of the day and months of the year for days which were calm. Some data is also given as to the effect of varying meteorological conditions. J. M. HOUGH

551.594.12

11653. On the ionization produced by gamma radiation from the ground and from the atmosphere. V. F. HESS. *J. geophys. Res.*, **58**, 67–72 (*March*, 1953).

Two new methods for quick determination of the ionization produced by the γ-rays from the radioactive substances in the ground are discussed. The first ("absorption method") utilizes partial screening of a portable ionization meter with a lead shield of 1 cm from the bottom and from the sides, and empirical determination of its absorbing power. This method was tried out in field experiments and its results agree very well with the results obtained with the conventional method (alternative measurements over soil and over water). The second method ("well method") consists in placing a cylindrical ionization chamber inside an iron housing with a wall 10 cm thick, but open at the top and on the bottom. The chamber is used in two positions inside this "iron well" and from the difference of ionization observed at these two positions the total value of the terrestrial γ-radiation can be derived. Both methods can also be used for determining the γ-radiation coming from the atmosphere ("air radiation"); however, the smallness of this effect makes it difficult to get reliable results. Discrepancies arising in this case are discussed. A.

551.594.12

11654. Study of atmospheric ions in a non-equilibrium system. C. G. STERGIS. *J. geophys. Res.*, **59**, 63–6 (*March*, 1954).

The time variation of the concentration of atmospheric ions in a non-equilibrium system has been determined experimentally and theoretically. The results indicate that ionic equilibrium, once disturbed, may not again be attained until a time up to 15 min has elapsed. A.

551.594.12

11655. Ions and condensation nuclei in the atmosphere, balance of ions and value of cosmic radiation at sea level. J. CLAY. *J. atmos. terrest. Phys.*, **3**, 132–40 (*April*, 1954).

In connection with a publication by Hess and Vancour [Abstr. 9163 (1950)] different instances are quoted of measurements of condensation nuclei over the ocean. Numerical results are given of investigations of balance of ions and ionization by cosmic radiation at sea level. The point is made that the number of ions per cm^3 permanently present in the atmosphere cannot cannot serve as a basis for the calculation of the balance, and two new methods are described. A.

551.594.12

11656. Remarks on the article of J. Clay: "Ions and condensation nuclei in the atmosphere, balance of ions and value of cosmic radiation at sea level." V. F. HESS. *J. atmos. terrest. Phys.*, **4**, 343–5 (*Jan.*, 1954).

See preceding abstract.

551.594.12

11657. Radon, thoron, and their decay products in the atmosphere. V. F. HESS. *J. atmos. terrest. Phys.*, **3**, 172–8 (*April*, 1954).

The ionization produced by the α-rays of radon, thoron and their successive products in the atmosphere was measured from October, 1949 to July, 1950. The results of the observations in November and December have been published previously by Hess and Vancour [Abstr. 9163 (1950)]. On account of an error which was overlooked at that time the whole series of observations had to be recomputed, including the unpublished results of 1950. Samples of air from outdoors were filled into a large ionization chamber which was evacuated previously and was standing in an iron house with walls thick enough to shield off local γ-rays. The background was so low that it was possible to measure the ionization by α-rays of the products filled into the chamber and to follow up its diminution for several days. It was found that the average radon content amounted to 54×10^{-18} curies per cm^3. The total average ionization produced by the α-rays from radon and its decay products was about $0 \cdot 70\ I$ while thoron and its decay products give $0 \cdot 54\ I$, or about 44% of the total ionization due to α-rays. A.

551.594.12 : 539.165

11658. The intensity of beta ray ionization of potassium, uranium and thorium. R. I. WELLER. *J. atmos. terrest. Phys.*, **5**, 1–10 (*March*, 1954).

A study of the absolute intensity of β-ray ionization from potassium salts and the ores of uranium and thorium is presented. Ratios of β- to γ-radiation above an infinite body were calculated for these substances. Close to the surface of the earth, β-radiation is calculated to cause much more ionization than γ-radiation. The β-radiation decreases so rapidly that above 100 cm the γ-rays are the principal ionizers from the earth. A.

551.594.13

11659. Electric conductivity and small ion concentration of the atmosphere at one metre above ground and conductivity at ground level. G. A. O'DONNELL. *J. atmos. terrest. Phys.*, **2**, *No.* 4, 201–15 (1952).

The diurnal variation of the polar conductivities of the atmosphere was obtained at ground level and at 1 m above ground at five locations in and within 120 miles of New York City. The diurnal variation in the concentration of small ions of both signs at 1 m above ground was found simultaneously with the conductivity measurements. Results show that the polar conductivities at ground level are not equal to the respective values at 1 m and the ratios of the polar ground conductivities to the corresponding metre values are not constant. Factors such as meteorological changes and local air conditions do not affect conductivity at both levels equally. The total conductivity at ground level is in general not equal to the total conductivity at 1 m nor is the ratios of these quantities constant. Some of the factors causing variation in the concentration of small ions have a parallel effect on the average mobilities of the ions in a given mobility range. Thus variation in conductivity is dependent not only on the concentration of small ions but also on their average mobilities. An explanation is offered for the apparent fact that while the electric field of the earth shows little difference from the ground level up 1 m above ground, conductivity may differ considerably between the two levels. A.

551.594.13

11660. Atmospheric electrical conductivity near the earth's surface. J. A. Chalmers. Note in *J. atmos. terrest. Phys.*, **3**, 223–4 (*May*, 1953).

Discrepancies between the measurements of O'Donnell (1951, 1952) and Hogg (1939) of the polar conductivities of the atmosphere near the earth's surface are shown to be due to the different conditions of measurement. A.

551.594.14

11661. First measurements on the radioactivity of atmospheric precipitations. L. Santomauro and A. Cigna. *Ann. Geofis.*, **6**, 381–7 (*July*, 1953) *In Italian.*

Tests were made from Feb., 1951, to Nov., 1952, using a G.M. counter. The activity was not constant: it became greater after atomic experiments at Las Vegas, Eniwetok and Montebello Is. Therefore these facts are probably associated. The activity increased about 8 days after Las Vegas experiments, 2 weeks after Eniwetok experiments and about 3 weeks after Montebello Is. explosions. γ- and β-rays of the precipitates were measured and the background of cosmic-radiation was considered in drawing the diagrams. A.

551.594.21

11662. Field intensities and charge densities in thunderclouds. H. Norinder and W. Pucher. *Ark. Geofis.*, **2**, *Paper* 5, 97–107 (1954).

The fields at the underside of a cloud and at the earth's surface below are computed on the assumption that the cloud is ellipsoidal in shape. By comparing with field intensities experimentally determined at the earth's surface, values for the cloud charge and charge density are obtained. The values found were from about 1 to 2×10^{-5} e.s.u./cm². The corresponding maximum field intensities are from 1 to 5 kV/cm. In this connection, the question of the conditions under which a lightning discharge may be initiated is examined. A.

551.594.21

11663. Electric-field regeneration in thunderstorms. R. Gunn. *J. Meteorol.*, **11**, 130–8 (*April*, 1954).

A season's record of the electric-field intensity measured on the earth during active thunderstorms is evaluated. The records show that two basic types of storms exist. The most common, or positive, type of active storm systematically induces positive electricity on the earth. The normal systematic increase in electric field is interrupted and partly neutralized or over-neutralized by two types of lightning discontinuity. The most frequent electrical discharges reduce the field only by a small fraction. After four to ten fractional decreases in field, a large change is observed that frequently reverses the field. Negative storms that systematically induce negative charge on the earth occurred infrequently, as did storms of the mixed type. The fundamental cloud-charging mechanism is formulated in quantitative terms. The analysis suggests that two basic time intervals related to the observed field discontinuities are associated with thunderstorm electricity. The first is the regeneration time necessary for the falling rain to raise the electric field to the critical breakdown field for air. The second is the relaxation time required to distribute free electrical charge through the thundercloud by conduction. The regeneration time in active storms is always a fraction of the relaxation time. The quantitative formulation is compared with observed measurements made inside an active thunderstorm, and it is concluded that electrified falling rain is just adequate to describe the observed phenomena. A.

551.594.21 : 537.221

Electric charges from ice friction. *See Abstr.* 11023

551.594.22

11664. The relation between point discharge current and field. J. A. Chalmers. *J. atmos. terrest. Phys.*, **2**, *No.* 5, 292–300 (1952).

The empirical relation $I = A(F^2 - M^2)$ of Whipple and Scrase is derived theoretically on certain assumptions involving space charges. The factors concerned in the values of A are discussed. A.

551.594.22

11665. Point discharge currents. J. A. Chalmers. *J. atmos. terrest. Phys.*, **2**, *No.* 5, 301–5 (1952).

It is shown theoretically that the total point discharge current below a cloud is nearly independent of the nature of the points, so that point discharge currents significant in the maintenance of the earth's charge are not confined to forest and mountain areas. It is also shown that a lightning conductor will have practically no influence upon the probability of a lightning flash occurring. A.

551.594.221

11666. A comparison of the rates of change of current in the step and return processes of lightning flashes. D. B. Hodges. Note in *Proc. Phys. Soc.* [*London*] *B*, **67**, 582–4 (*July*, 1954).

Histograms are given showing the ratios of the rates of change of current in the return strokes and in the steps of α- and β-type leader strokes in South Africa. From values of current steepness in typical lightning flashes obtained by various authors the mean currents flowing in the steps of α- and β-leader strokes are found to be 620 and 2600 A respectively. R. H. GOLDE

551.594.5

11667. The geometry of radio echoes from aurorae. S. Chapman. *J. atmos. terrest. Phys.*, **3**, 1–29 (*Jan.*, 1953).

It is shown that the points P on auroral rays, whence a radio beam from a station Q can be reflected back to Q, lie on a cubic surface (the echo surface), if the auroral rays are taken to lie along the lines of geomagnetic force, and the earth's field is treated as a centred dipole field. There is an echo surface for each point Q. The nature of the surface is examined in detail, for guidance in the planning of auroral observation by radio reflections. So far as purely geometrical considerations are concerned, a northern station Q can receive echoes not only from the aurora borealis, but also, from above the atmosphere, from the stream of particles descending to the southern hemisphere to produce the aurora australis. But it is uncertain whether these streams of solar particles will have sufficient electron density to give observable transequatorial (or extra-terrestrial) echoes. A.

551.594.5

11668. The streaming of charged particles through a magnetic field as a theory of the aurora. B. C. Landseer-Jones. *J. atmos. terrest. Phys.*, **3**, 41–57 (*Jan.*, 1953).

A stream of charged particles is considered, which moves through a magnetic field without collisions and remains everywhere neutral. It is assumed to start from a region where the velocity and density of the particles are uniform and there is no magnetic or electric field. Expressions for the conservation of vorticity and energy are derived and an electric field shown to be necessary to maintain the stream's neutrality. In the case of steady motion, these lead to relations which can be used to estimate the spatial distribution of the stream and of the magnetic field from a knowledge of the initial conditions and the magnetic field when the stream is absent. They show that the stream must in certain cases flow all round a magnetic dipole. If the stream has properties likely for one coming from the sun, the theory shows that particles from most points on its inner boundary cannot reach the earth's surface in low enough latitudes to give aurorae. Particles may still reach arcs of the auroral zone from a small region of the stream, and this possibility is discussed as the most likely explanation of aurorae based on the initial conditions assumed. A.

551.594.5

11669. Scale height determinations and auroras. D. R. Bates and G. Griffing. *J. atmos. terrest. Phys.*, **3**, 212–16 (*May*, 1953).

It is shown that the method hitherto used for determining scale heights from auroral luminosity curves is invalid. A revised treatment of the effects produced by incoming electrons is not attempted. Instead the simpler case of incoming protons, interest in which has been revived by the recent work on hydrogen line emission, is considered. If protons are responsible for aurorae the possibility of deducing scale heights is slight, for complicating factors appear to enter. Thus the calculated luminosity curves for the lower aurorae are so sharp that they cannot be reconciled with the observed curves by any reasonable change in the scale height, and it is necessary to invoke some arbitrary assumption such as that the incoming protons have a wide energy spread. In striking contrast no marked inhomogeneity is indicated for the higher aurorae. A.

551.594.5

11670. Radio reflections from aurora. B. W. Currie, P. A. Forsyth and F. E. Vawter. *J. geophys. Res.*, **58**, 179–200 (*June*, 1953).

For the three frequencies investigated—3000, 106 and 56 Mc/s—echoes have been observed with the last two. Echoes occur when the auroral forms exhibit some ray structure and, then, only from parts of the aurora at elevations less than 15° above the horizon. It is shown that the echoes originate from levels close to the lower edge of the aurora. Height distributions of the centres from which the echoes come agree closely with height distributions found from parallactic photographs of aurora in other regions. The 106 Mc/s echoes are found to occur most frequently within the auroral zone and the 56 Mc/s echoes some distance to the south. Relative frequencies and diurnal variations of the two groups of echoes, as well as their heights and geographical distributions, indicate that echoes originate from a threshold process. It is suggested that the echoes arise by critical reflection from centres of high electron density ($1 \cdot 4 \times 10^8$ and 4×10^7 electrons per cm^3, respectively) that are formed close to but above the levels where the electron collision frequency exceeds the gyro-frequency of the electrons. A.

551.594.5

11671. Atomic and molecular transitions in auroral spectra. J. W. Chamberlain and N. J. Oliver. *J. geophys. Res.*, **58**, 457–72 (*Dec.*, 1953).

The identifications of lines and bands in auroral spectra, as reported by several observers over the past few years, are subjected to a critical analysis in order to determine which atomic transition arrays and molecular progressions are most important. The various transitions are analysed from the standpoint of expected relative intensities of lines or bands originating from common upper levels, and the probable validity of the identifications is discussed. Tables are presented listing the emissions that seem to be well established in at least some auroral displays. Variations in auroral spectra with latitude, type of display, etc., undoubtedly account for many of the discrepancies among the wavelength lists of different authors. Hence it is not always possible to differentiate between real and fortuitous identifications. A large number of fainter lines and bands still remain unidentified. A.

551.594.5

11672. Intensity distribution among nitrogen bands in the auroral spectrum. M. E. Pillow. *Proc. Phys. Soc.* [*London*] *A*, **67**, 780–8 (*Sept.*, 1954).

The factor $p = [\int \psi_{v'} \psi_{v''} dr]^2$, occurring in transition probabilities between vibrational levels, has been calculated for a number of transitions of nitrogen molecules. Intensities obtained from these values have been used to investigate the distribution of intensities among bands in auroral spectra. A.

551.594.5

11673. Radio reflections from aurorae. K. Bullough and T. R. Kaiser. *J. atmos. terrest. Phys.*, **5**, 189–200 (*Sept.*, 1954).

An interpretation of auroral echoes observed at Jodrell Bank on two occasions in 1953. It is concluded that in each case the echoes are due to direct, non-specular reflection from an auroral arc extending more than 1000 km along a parallel of geomagnetic latitude. The reflection apparently occurs in a region of the arc of limited vertical extent at a height of about 125 km. The observed line of sight velocities of intense reflecting centres are interpreted as true motions along the arc with velocities of the order of 1–2 km sec^{-1}. A.

551.594.5

11674. Magnetic self-focussed solar ion streams as the cause of aurorae. W. H. BENNETT AND E. O. HULBURT. *J. atmos. terrest. Phys.*, **5**, 211–18 (*Sept.*, 1954).

The theory of magnetic self-focused solar ion streams assumes that a jet of equal numbers of fast-moving positive ions and negative electrons emerges from the sun. As the jet proceeds through the corona the fast electrons are scattered out more rapidly than the ions and are replaced continually by slow electrons. The excess of fast ions over fast electrons results in an electric current whose magnetic field repels the remaining fast electrons from the stream but exerts little magnetic force on the slow electrons. The excess positive charge electrically repels the slow positive ions, but exerts little magnetic force on them. Thus the stream continues to repel fast electrons and slow ions while retaining fast ions and slow electrons. At all times all parts of the stream and surrounding gas are closely (but not exactly) electrically neutral. For a proton stream which carries sufficient energy for an aurora the density of space ionization between the sun and the earth is calculated to be at least about 10^{-4} electron ion pairs cm^{-3} to support magnetic self-focusing. The speed of the auroral ions is estimated to be about 10^{10} cm/sec. The auroral display is supposed to be due both to energy transferred to the atmosphere from the ions on their way in and to atmospheric oxygen and nitrogen particles blown outward, and made luminous, as a result of the energy and charge of the ions dissipated in the upper atmosphere. A.

551.594.5

11675. The excitation of hydrogen in aurorae. J. W. CHAMBERLAIN. *Astrophys. J.*, **120**, 360–6 (*Sept.*, 1954).

The Balmer emission produced when protons penetrate the atmosphere during an aurora is investigated by the method of statistical equilibrium. The Hα luminosity *versus* height is computed for several incident proton energies and is compared with computations for the luminosity distribution in other emissions. It is found that each incident proton should produce a total of about 50 quanta of Hα, which leads to a rough estimate for the proton flux of about $6 \times 10^7\ cm^{-1}\ sec^{-2}$ during the arc stage of a moderately strong aurora. The Balmer decrement is computed, and the theoretical Hα profile for an arc in the magnetic zenith is compared with Meinel's observed profile. This comparison suggests that the incident protons undergo considerable scattering, which produces a rather large effect on the observed profile and the luminosity distribution. A.

551.594.5 : 535.338.4

The intensity distribution in the second positive band system of nitrogen in a laboratory light source and in the aurorae. *See Abstr.* 10946

551.594.5 : 551.593.9

11676. On the production of glow discharges in the ionosphere by winds. O. R. WULF. *J. geophys. Res.*, **58**, 531–8 (*Dec.*, 1953).

It is suggested that a source of excitation of the airglow and aurora is to be found in potential differences generated by zonal ionospheric winds cutting the earth's magnetic field. A return path of current flow (glow discharge) in the higher ionosphere appears plausible. The principal effect in this process arises from the cutting of the vertical component of the field by broad horizontal winds. An auroral zone results as the region where the product of wind velocity and vertical field intensity has a maximum. From this point of view, the aurora and the airglow (at least a portion of it) are manifestations of the same thing. The aurora occurs under high excitation when the winds are strong in high latitudes, while this portion of the air-glow is always present in some measure in most latitudes, arising from lower velocity winds. Patterns in the large-scale air circulation should lead to patterns in the intensity of the emission, and the regular diurnal disturbance of these upper atmosphere zonal winds should lead to diurnal features in the aurora and airglow. A.

551.594.5 : 621.396.11

11677. Radio measurements and auroral electron densities. P. A. FORSYTH. *J. geophys. Res.*, **58**, 53–66 (*March*, 1953).

Radar echoes from aurora have been recorded simultaneously at frequencies of 56 and 106·5 Mc/s. The ratio of the echo amplitudes at the two frequencies varies between wide limits. An attempt is made to reconcile the experimental evidence with (1) partial reflections from the surfaces of large ionized regions in the aurora, (2) scattering from inhomogeneities in the auroral ionization, and (3) critical reflections from small volumes of intense ionization. It is concluded that (3) is responsible for the typical auroral echoes which are observed at Saskatoon, although (2) may be responsible for echoes of small amplitude which are often observed in the early stages of an auroral display. If these conclusions are correct, electron densities of $10^8/cm^3$ may occur occasionally in small volumes of the aurora. A.

551.594.6

11678. A search for radio echoes of long delay. K. G. BUDDEN AND G. G. YATES. *J. atmos. terrest. Phys.*, **2**, *No.* 5, 272–81 (1952).

A description is given of some attempts to detect long delayed radio echoes of the type reported by van der Pol, Stormer and others, with delays between 3 sec and 15 sec. It has been suggested that such echoes might arise by reflection from ionized corpuscular streams from the sun. To investigate this, frequencies were used which would penetrate the ionosphere at most times of day, and it was also necessary to use the highest possible transmitter power. No echoes of long delay were observed. Owing to the large number of short wave commercial transmitters now operating, the interference level was probably far higher than it would have been in 1928. Nevertheless, it is possible to estimate the minimum signal power which could be detected by the receiving apparatus. The probable size and density of the clouds of ions emitted from the sun is then examined, and it is concluded that such clouds are not likely to be dense enough to give detectable radio echoes. It is tentatively suggested that the echoes of long delay heard by previous observers were associated in some way with ionized regions fixed relative to the earth, and that the failure to observe echoes in the present investigation was due to the choice of frequencies which were too high. Some suggestions are made for the planning of future attempts to observe long delayed echoes. A.

BIOLOGY 57/59

578.087.7 : 534.24

11679. The use of ultrasonic reflectoscope for the continuous recording of the movements of heart walls. I. EDLER AND C. H. HERTZ. *K. Fysiogr. Sällsk. Lund Förhandl.*, **24,** *No.* 5, 19 *pp.* (1954).

It has been shown that it is possible to locate blood–heart wall boundaries by the supersonic reflectoscope method, using frequencies of about 2·5 Mc/s. The method was applied for the locating of heart walls on living human beings and continuous registration of movements of the heart walls was found possible. Recordings are shown of the movements of the left ventricle wall in the normal and in the diseased heart. Further, movements of the left atrial wall in mitral stenosis were recorded. A.

578.087.8 : 535.43.07

A nephelometer of wide range for bacteriological use. *See Abstr.* 10982

578.088.5 : 535.21

11680. Biological action of light and radiation. R. SCHULZE. *Lichttechnik*, **6,** 250–5 (*July*, 1954) *In German.*

The various types of radiation reaching the earth's surface are first described. The atmosphere filters out all except two bands, viz. (*a*) the visible and near infrared and (*b*) a wide band of wavelengths centred on 1 m. The effects of radiation of different wavelengths on the human body are next discussed and the results of deprivation, of over-exposure and of seasonal variations are described, as far as they are known at present. J. W. T. WALSH

578.088.7

11681. Polar cardioscope. J. W. TRANK AND O. H. SCHMITT. *Rev. sci. Instrum.*, **25,** 918–20 (*Sept.*, 1954).

In the polarcardioscope, the electrocardiogram is recorded radially on a circularly swept trace about 10 in. in length. A long-persistence screen cathode-ray tube is used, the angular sweep speed being adjusted to match the heart rate. Under these circumstances it becomes very simple to examine the details of the repeated beat, to compare successive superimposed beats, to detect arrhythmias, and to measure average frequency. The instrument is simple and comparable in bulk with an ordinary cathode-ray oscilloscope. It derives its input signal directly from any ordinary electronic electrocardiographic recorder. A.

MEDICAL SCIENCE . HUMAN PHYSIOLOGY 61

612.841

11682. Light absorption by the lens of the human eye. R. A. WEALE. *Optica Acta*, **1,** 107–10 (*Sept.*, 1954).

The spectral absorption of two fresh human lenses has been measured between 420 and 650 mμ. The results are compared with other data relating to preretinal filters. It is concluded that valid retinal sensitivity curves of a particular eye can be obtained only when the absorption characteristics of the preretinal media of that particular eye are known. A.

612.843

11683. Stiles–Crawford effect in extrafoveal vision. M. AGUILAR AND A. PLAZA. *An. Real Soc. Españ. Fís. Quím.*, **50**(A) 119–26 (*May–June*, 1954) *In Spanish.*

The Stiles–Crawford effect is studied in photopic extrafoveal vision. The results for extrafoveal regions up to 20° show a maximum efficiency when the entrance point is in the region of the pupil opposite to the part of the retina where the image is formed. For higher angles the position of the entrance point giving the maximum efficiency changes to the other part of the pupil. A theoretical interpretation is given for these variations. A.

612.843.31

11684. Sensations aroused by monochromatic stimuli and their prediction. L. C. THOMSON. *Optica Acta*, **1,** 93–101 (*Sept.*, 1954).

The appearance of the spectral colours has been recorded by a naming technique. The method is based upon the presentation of the test colours in random order. The wavelengths are seen within white surrounds of varying chromaticity. Four points, orange, yellow, green and blue-green are determined for four surround illuminations. Müller's theory of colour perception is partly successful in predicting the wavelengths of the spectrum at which these colours are seen. Both the results and the colorimetry necessary for their predication refer to the same eye. A.

612.843.613

11685. The order of coincidence required for visual threshold. G. S. BRINDLEY. *Proc. Phys. Soc.* [*London*] *B*, **67,** 673–6 (*Sept.*, 1954).

It is proved that the limiting hypothesis of an infinite number of identical independent units each depending for excitation on the scoring of a twofold quantum coincidence implies a steeper frequency-of-seeing curve than any other strictly two-quantum hypothesis and than the quasi-two-quantum hypothesis suggested by Bouman and van der Velden to account for large-field frequency-of-seeing curves. Published experimental curves for large and long flashes are steeper than those implied by the limiting two-quantum hypothesis or by the corresponding three-quantum hypothesis. It follows that the order of coincidence upon which the threshold for such flashes depends is at least fourfold. A.

612.845

11686. Pupillary psychosensory restitution and aging. L. S. KUMNICK. *J. Opt. Soc. Amer.*, **44,** 735–41 (*Sept.*, 1954).

The possible changes in pupillary psychosensory restitution (PPR) occurring with age were investigated by means of pupillography. Measurements of pupillary size and motion were obtained from a group of 94 ostensibly normal, white, male and female subjects ranging in age from 7·5 to 90·8 years. The results indicate (1) statistically significant differences in the PPR occurring with age as reflected in a progressive decrease in mean maxima and minima pupil diameters, extent of constriction and response velocity; (2) in general, a progressive increase in the variability of the response with age; (3) a significant, linear and negative relationship between age and the PPR, the correlation coefficients ranging from $-0{\cdot}53$ to $-0{\cdot}72$ ($df = 91$); (4) a significant relationship between pupil size in the dark and in the light, the correlation coefficient being 0·92; (5) that the relationship in (4) is not attributable to the accompanying decrease in size, since the partial correlation coefficient for the partial correlation between pupil size in the dark and in the light, with the effect of age held constant, is 0·86; and (6) that sex and eye colour are not factors in this study. Autonomic nervous system response (revealed in the PPR) and age are variables which should be considered in investigations on pupil size and motion, intensity discrimination, brilliance-function, relative luminosity and visual fields. A.

612.858

11687. Acoustical measurements on a mechanical model of the inner ear. A contribution to the hydrodynamics of the cochlea. H.-G. DIESTEL. *Acustica*, **4**, 421–31 (1954) *In German.*

A mechanical model of the inner ear with on the average 55-fold exaggeration of scale has been constructed. The frequencies are so transformed that velocities and impedances in model and ear are nearly the same. In this model, the pressure in the liquid, the motion and impedance of the membrane as well as the entry impedance of the "oval window" are measured in magnitude and phase, with good agreement between theory and experiment. The deflections of the membrane and the vortices in the liquid at various frequencies are photographed. A.

614.485

11688. Some data and material constants in relation to ultraviolet radiation. G. SILJEHOLM AND G. GÜNTHER. *T. Ljuskultur*, **26**, 35–44 (*April–June*, 1954) *In Swedish.*

The wavelength range considered is 2000–4000 Å. The flux which has the same erythema-effect as 10μW at 2967 Å is the unit *E*-viton. The disinfectant action, transparency of air, glass, water and some plastics, absorption and reflection by various substances, are discussed as functions of wavelength, and numerous values are tabulated. Some photochemical reactions are mentioned. J. A. WILCKEN

614.898 : 539.185

11689. The lethal flux of neutrons at energies up to 3 MeV. L. CAVE. *Brit. J. Radiol.*, **27**, 273–82 (*May*, 1954).

The 50% lethal flux of neutrons at energies up to 3 MeV is calculated from the assumptions that (*a*) the 50% lethal dose of γ-rays is 400 r, (*b*) the relative biological efficiency of protons is 6·5 and (*c*) the criterion for lethal effects is the equivalent amount of ionization produced in the whole body. For isotropic incidence the 50% lethal flux varies from $1{\cdot}6\times10^{12}$ n/cm^2 at thermal energy to $1{\cdot}7\times10^{10}$ n/cm^2 at 3 MeV. 3 appendixes deal with the geometry of dose rates. A.

615.849 : 616.073.75

11690. Recommendations of the International Commission on Radiological Units. *Brit. J. Radiol.*, **27**, 243–5 (*April*, 1954). *Amer. J. Roentgenol.*, **71**, 139–42 (*Jan.*, 1954).

616–073.75

11691. Surface back-scatter in the 100 kV to 400 kV range. H. E. JOHNS, J. W. HUNT AND S. O. FEDORUK. *Brit. J. Radiol.*, **27**, 443–8 (*Aug.*, 1954).

Careful measurements of surface backscatter are described, using an "air-wall" thimble chamber 6 mm long and 3 mm in diameter in a water phantom. Detailed graphs and tables of results are given. The effect of end covers for X-ray applicators on surface backscatter is discussed. D. V. MABBS

TECHNICAL MATERIALS 66/67

666

11692. The glass sealing properties of titanium and zirconium. H. RAWSON AND E. P. DENTON. *Brit. J. appl. Phys.*, **5**, 352–3 (*Oct.*, 1954).

Titanium and zirconium may be sealed to standard sealing glasses without the need for any special sealing techniques, to give strong vacuum-tight seals with low stresses in the glass. If a flame-sealing method is used it is necessary to keep the sealing time as brief as possible, since the expansion characteristics of both metals change appreciably on prolonged heating in air. A.

666.1.037.5

11693. Compressed glass-to-metal seals. H. ADAM. *J. Soc. Glass Technol.*, **38**, 285 T–296 T (*June*, 1954).

A detailed study is made of theory and practice regarding the compression factor in different types of glass-to-metal seals. A.

PHOTOGRAPHY 77

771.351 : 535.317.25

Method for determining the resolving power of photographic lenses. *See Abstr.* 10923

778.34 : 53

Summer School lectures on particle track photography. *See Abstr.* 10767

778.34 : 537.534.75

New method of determining masses of charged particles in photographic emulsions. *See Abstr.* 11142

778.34 : 537.534.75

Calculation of range/energy relations especially in photographic emulsions. *See Abstr.* 11143

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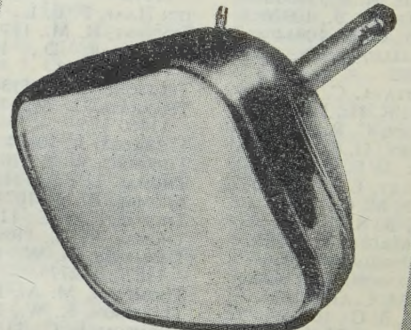

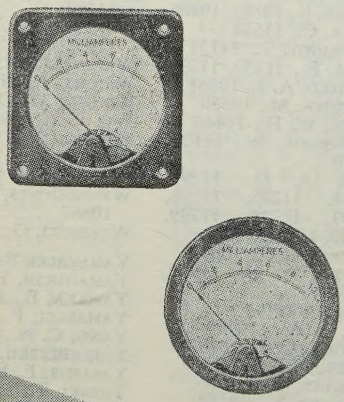

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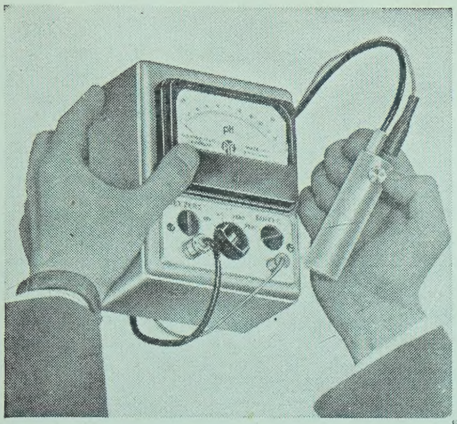

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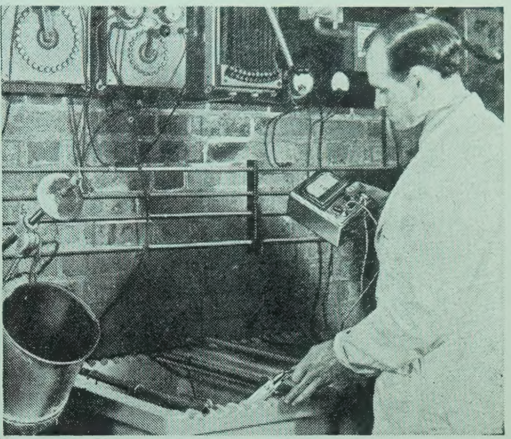

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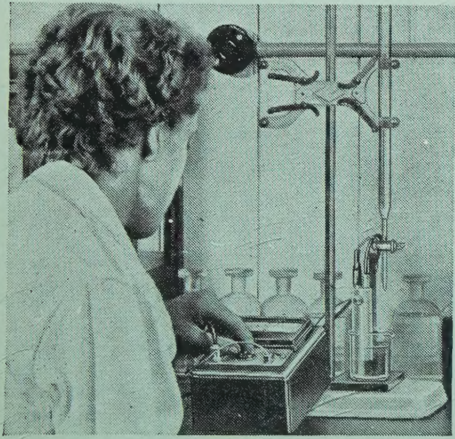

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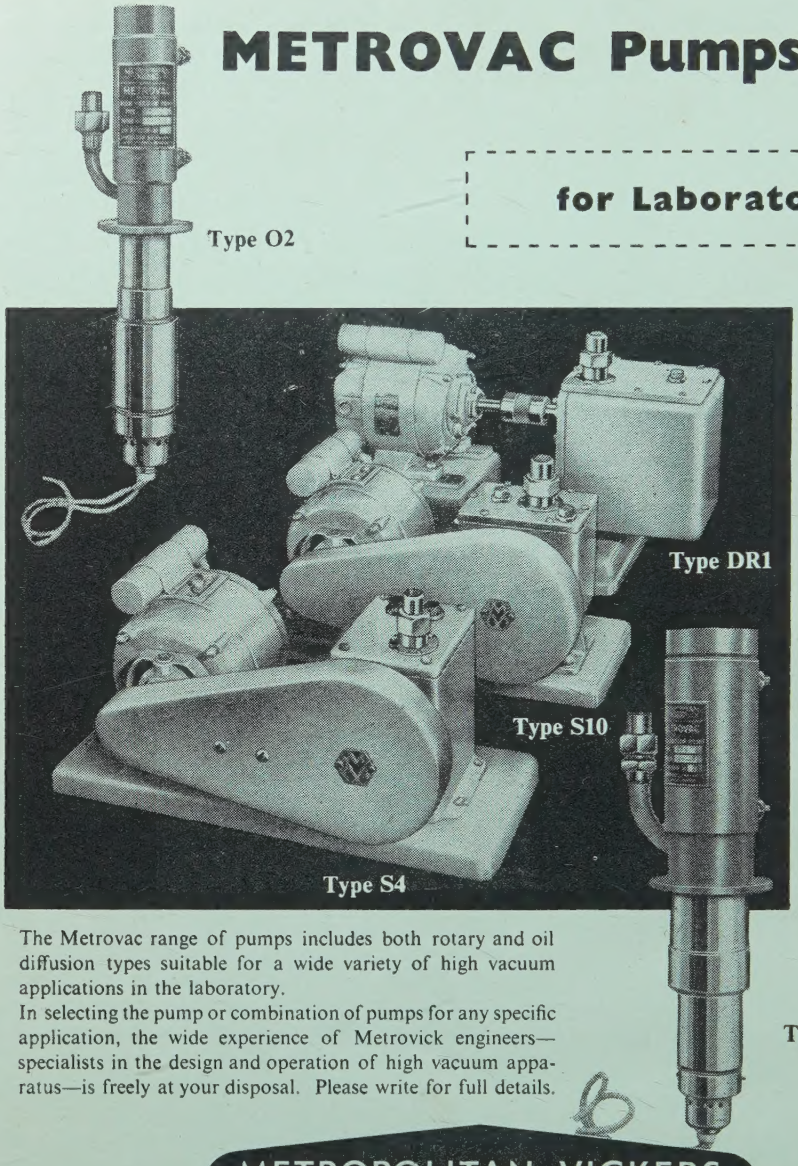

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